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DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
O. H. TITTMANN
SUPERINTENDENT

GEODESY

THE CALIFORNIA-WASHINGTON ARC OF PRIMARY TRIANGULATION

BY

A. L. BALDWIN
Computer, U. S. Coast and Geodetic Survey

SPECIAL PUBLICATION No. 13

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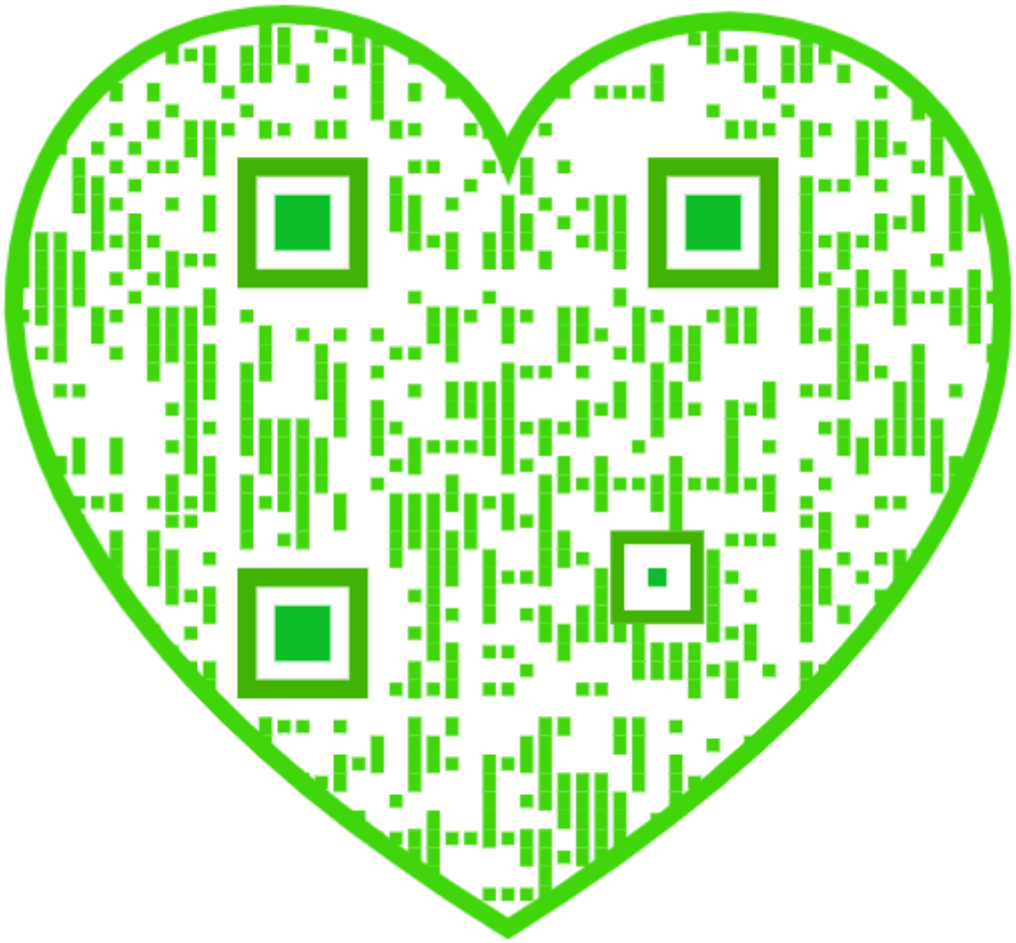

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THE CALIFORNIA-WASHINGTON ARC OF PRIMARY TRIANGULATION.

By A. L. Baldwin.

Computer, United States Coast and Geodetic Survey.

GENERAL STATEMENT.

In the spring of 1903 the United States Coast and Geodetic Survey began the reconnoissance for an arc of primary triangulation to extend from the primary triangulation in northern California to Puget Sound. The work of reconnoissance was not done continuously in any one season, but was done a little at a time, in order to interfere as little as possible with the observations. It was usually done slightly in advance of the triangulation, but at times simultaneously with it, and so the two can not be discussed separately. The observing was completed in four summer seasons, beginning in June, 1903, and ending in July, 1906.

The length of the primary triangulation of this arc, along the axis of the scheme, is 577 miles (929 kilometers) and the length of the subsidiary schemes, secondary in character, is about 30 miles (48 kilometers). Fifty-seven stations constitute the main scheme. The mean latitude of the three old stations of the Thirty-ninth Parallel triangulation, from which the arc started, is 39° 05′, and the northernmost point lies in latitude 47° 23′. The triangulation follows closely the meridian of 122° 30′.

The positions and descriptions were prepared for publication by Mr. C. H. Swick.

The greater portion of the work of making the difficult least square adjustments was done by Mr. E. H. Bowen and Mr. M. H. Doolittle, the adjustment of the elevations from the vertical measures having been made by the latter.

The engineer intent only upon securing the necessary information to enable him to extend his triangulation or to base other surveys upon it will find the information he desires on pages 31–78, commencing with the explanation of the table of positions, lengths, and azimuths. The index printed on pages 75–78, used in connection with the sketches at the end of the publication, will enable him to find quickly the data for any given locality.

There were used to control the lengths in this triangulation the Yolo base in California, the Willamette base, near Eugene, Oreg., and the Tacoma base, near Tacoma, Wash.

The Yolo base was measured in 1881 by Assistant George Davidson, who published his report as Appendix No. 8 in the Report of the Coast and Geodetic Survey for 1882. The Willamette and Tacoma bases were measured by the party of Assistant O. B. French in 1906.[1] During this season of 1906 six primary bases were measured, the other four being a part of the Ninety-eighth Meridian triangulation. Complete measurements were made on each base with 50-meter steel tapes and also with invar tapes of the same length.

PROGRESS OF THE TRIANGULATION.

SEASON OF 1903.

Early in 1903 Assistant O. B. French was placed in charge of the field work and in April organized at Eugene, Oreg., a reconnoissance and building party, consisting of a foreman and four men, with a wagon and four horses. With this party Mr. French conducted a recon-

[1] See Appendix 4, U. S. Coast and Geodetic Survey Report for 1907, "Six primary bases measured with steel and invar tapes.

noissance through the Willamette Valley to connect with the triangulation of the Columbia River. By the latter part of May this was so far advanced that the observing could be started and a party, consisting of Mr. French, a recorder, and four other men, with two wagons and seven horses, started out from Eugene for the first station, Roman, leaving the first party to build signals. The work was pushed toward the Columbia River as far as the reconnoissance had been completed. Before the end of September both parties returned to Eugene, where a base and its connections with the main scheme were laid out and a part of the stations were occupied by the middle of October. Throughout the season the signal-building party was always in advance of the observing party, erecting signals, cutting lines, opening trails, and preparing camping grounds. The weather during the whole season was very disagreeable and uncertain and the cause of much lost time, especially by the observing party, as it was rare that all the signals to be observed at a station were visible at one time. There were frequent long intervals of many days when no observations could be made.

Between the middle of October and the middle of November Mr. French and the foreman of the signal party made a reconnoissance southward to connect with the triangulation of the Thirty-ninth Parallel, developing the scheme that with few changes was carried out in 1904.

SEASON OF 1904.

In the season of 1904 the organization of the parties and the method of conducting the work were about the same as in 1903. Assistant J. S. Hill was also assigned to the work, thus enabling Assistant French to devote more time to reconnoissance without delaying the progress of the observing party. The parties were organized in April, when some additions were made to the reconnoissance to complete the scheme between the Thirty-ninth Parallel triangulation and the work of the previous season, and a few stations were prepared for observations. The observing started at Marysville Butte soon after May 1 and the season's work closed about the middle of November. During this time the whole scheme between the old triangulation of the Thirty-ninth Parallel and the work of the previous season was completed. Between July 9 and August 10 Assistant French made a reconnoissance to connect the work of the Columbia River with that of Puget Sound, which practically settled the scheme of work for 1905.

Many difficulties were encountered during the season. During April and May snow and very strong winds greatly delayed the work. At station Soda smoke delayed the party at one time for six weeks. Many stations were difficult of access. Five stations were reached by pack trains over distances from 10 to 25 miles and along difficult and dangerous trails. In each of two cases special trails had to be made for a distance of 4 miles and they were so steep that in one case two horses went over backwards and the outfit had to be packed by men. In order to reach station Mears it was necessary to use ladders and hand lines.

SEASON OF 1905.

During the season of 1905 the organization of the parties and method of conducting the work were the same as during the previous season. The field work began about the middle of April and closed about the middle of October.

The region between the Columbia River and Puget Sound is a very difficult one through which to carry a primary triangulation. Many of the peaks that must be used are flat and heavily timbered and the roads and trails are almost impassable. It is also a region of very bad weather and this fact, together with the prevalence of forest fires, made the delays in observing very great. The scheme that was laid out the preceding season proved to be entirely too expensive, on account of the very high signals required and the great amount of cutting of timber necessary. Further reconnoissance was therefore required and both parties took part in it. About June 1 the observing party began work in Oregon, completing the occupation of four stations in the Willamette base net. This party then moved to the vicinity of the Tacoma base and was engaged the rest of the month in signal building. Observing was resumed on July 1.

In spite of every effort the work connecting the Columbia River triangulation with that of Puget Sound was not completed during this season. Assistant French reported that the weather conditions during this season were the most unpropitious for such work that he had ever experienced.

At three stations signals over 100 feet high were built, one being 130 feet high. At several stations the instrument was mounted on a high tree. In such cases the tree was guyed with iron wires and a staging was built about the tree. At one station over 200 trees 4 feet or more in diameter and 200 feet high, besides many smaller ones, were cut to open lines. Long and dangerous trails had to be constructed and several accidents happened on them, which fortunately were not serious except to the horses. At the last station the party was caught in the snow and had difficulty in getting out.

SEASON OF 1906.

During this season the work was in charge of Assistant J. S. Hill, who organized a party on June 11 and finished the last station on July 26, completing the primary triangulation between the Columbia River and Puget Sound. He also made the connection between the primary triangulation and the Columbia River work. Between June 18 and July 26 the observing party occupied seven primary stations and incidentally traveled 250 miles by boat, 315 miles by wagon, and 130 miles by trail with pack animals.

METHODS OF OBSERVING EMPLOYED.

The observations for the primary horizontal angles were made in accordance with the General Instructions for Primary Triangulation, as given on pages 170–174 of Appendix 4, Report for 1911.

All the horizontal angle measures were made by the direction method, using the 12-inch (30-centimeter) theodolites made in the Instrument Division of the Survey. These instruments are described in Appendix 8, Report for 1904. The telescope used has a clear aperture of 61 millimeters and its focal length is 74 centimeters. The circle is graduated to five-minute spaces and is read by the micrometer microscopes to single seconds.

PROGRAM OF OCCUPATION OF STATIONS.

In the following three tables the primary stations occupied during the several seasons are arranged in the order of their occupation. The second column of each table indicates the days on which primary horizontal observations were made, and the third column the number of such days. The letters (az.) after the name of a station indicates that observations for primary astronomic azimuth were made at that station.

Stations occupied.

Assistant O. B. French, chief of party and observer.

SEASON OF 1903.

Station	Days on which observations of primary horizontal directions were made	Number of days
Roman	June 17, 18, 19, 20, 23, 25, 26, 28, 29	9
Spencer (az.)	July 7, 8, 9; Oct 12, 13, 14	6
Peterson	July 14, 15, 16	3
Mary (az.)	July 25, 26	2
Yam (az.)	July 31; Aug. 3, 4, 8, 9	5
Hult	Aug. 11, 12, 13, 16	4
Barnes (az.)	Aug. 27, 28, 30; Sept. 1, 2	5
Larch	Sept. 8, 13, 14, 15	4
Rauch	Oct. 1, 2, 6	3
Willamette south base	Oct. 7, 8, 10, 11	4

Stations occupied—Continued.

Assistant O. B. FRENCH, chief of party and observer, and Assistant J. S. HILL, observer.

SEASON OF 1904.

Station	Days on which observations of primary horizontal directions were made	Number of days
Marysville Butte	May 3, 4, 5, 6, 10	5
Snow Mountain east	May 16, 18	2
Kent (az.)	May 25, 26, 27	3
Lyons (az.)	June 3, 4, 5, 6	4
Round (az.)	June 11, 12, 13	3
Bally	June 16, 17, 18, 19	4
Mears	June 24	1
Spur	June 29, 30; July 1, 2	4
Gazelle (az.)	July 4, 5, 6, 8	4
Boliver	July 12, 13, 16, 18	4
Sterling	July 26, 27, 30	3
Soda	Aug. 3, 4, 12; Sept. 24, 25	5
Rust (az.)	Sept. 28, 29	2
Black	Oct. 3, 4	2
Onion (az.)	Oct. 12	1
White	Oct. 18, 19	2
Scott (az.)	Oct. 21, 22	2
Yellow	Oct. 27	1
Fairview	Oct. 31	1

Assistant O. B. FRENCH, chief of party and observer, and Assistant J. S. HILL, observer.

SEASON OF 1905.

Station	Days on which observations of primary horizontal directions were made	Number of days
Ridge	June 6, 7	2
Willamette north base	June 8	1
Twin	June 10, 11, 12	3
Peterson	June 13, 14	2
Neill 2	July 1	1
Wash	June 27, July 6, 7	3
Smelt	July 7	1
Dron	July 10	1
Gull	July 10	1
Kin	July 11	1
Tacoma astronomic station (az.)	June 21, 22	2
Bos	July 13	1
Burn	July 14	1
Tacoma south base	July 26, 27, 28, 29, 30	5
Tacoma north base	July 31, Aug. 2, 3	3
Hurst	Aug. 5	1
Pen	Aug. 6, 7, 8, 9	4
Bel (az.)	Aug. 18, 19, 20, 21	4
Huck	Sept. 6, 11	2
Hal	Sept. 1, 3, 4, Aug. 30, 31	5
Rain	July 22, Sept. 14, 15	3
Toutle	Sept. 21	1
Hurst	July 24, 25, Aug. 28	3

Stations occupied—Continued.

Assistant J. S. Hill, chief of party and observer.

SEASON OF 1906.

Station	Days on which observations of primary horizontal directions were made	Number of days
Barnes	June 14, 16, 17, 18	4
Red	June 23, 24, 25	3
Larch	June 30	1
Star	July 4, 5	2
Davis	July 10, 11, 12, 13	4
Lam (az.)	July 15, 16	2
Len	July 23, 24, 25, 26	4

STATEMENT OF COSTS.

The difficulty of separating the cost of the reconnoissance from that of the triangulation, where the two operations were carried on simultaneously, forbids an accurate statement of the cost of the former. It may fairly be stated that the time spent on the reconnoissance during the first three seasons was approximately 6. 2 months and the cost between $2500 and $3000. This makes the progress 93 miles per month and the unit cost not far from $4.80 per mile.

The following statement of costs for the triangulation may be considered correct. These costs are computed for the whole arc and include the salaries of the observers while in the field and during the limited times before and after each season while planning and reporting the work.

Number of months of observations	14.9	Cost per point determined	$192
Number of primary stations occupied	59	Number of miles of progress	577
Stations occupied per month	4	Cost per mile of progress	$61
Total field expenses	$35029	Area in main scheme in square miles	22100
Cost per station occupied	$594	Cost per square mile	$1.58
Total number of points determined	183		

STATEMENT OF ADJUSTMENTS.

No local adjustments were made, these having become unnecessary since the adoption of the present method of supplying missing observations in broken series.[1]

The line Snow Mountain west-Mount Helena had been fixed in length, direction, and position by the Thirty-ninth Parallel triangulation, and the result is published on page 539 of Appendix 9, Report for 1904. Similarly, the length, direction, and position of the line Marysville Butte-Mount Helena is published on page 540 of the same report. Marysville Butte was determined from eight stations of the Thirty-ninth Parallel triangulation, using six side equations, the angle equations being entirely lacking. The remaining parts of the triangle Snow Mountain west-Marysville Butte-Mount Helena were computed, and it was found that the two angles measured in 1904 required corrections of $-0''.71$ and $+1''.32$, respectively, to conform to the fixed computed angles. A single least square adjustment served for the entire primary scheme. The measured bases, Willamette and Tacoma, compelled the use of two length equations, and the Laplace azimuths[2] computed at Gazelle, Willamette, and Tacoma made three azimuth equations necessary.

ABSTRACTS OF HORIZONTAL DIRECTIONS AND ELEVATION OF TELESCOPE ABOVE THE STATION MARK.

All observed directions in the triangulation have been given equal or unit weight. Those directions were reduced to center where either the instrument or the object observed was not coincident with the center of the station mark.

[1] See Appendix 4, U. S. Coast and Geodetic Survey Report for 1911, p. 171.

[2] A Laplace azimuth (also called a true geodetic azimuth), as used in this publication, is one computed at a station of the triangulation from coincident longitude and azimuth observations, using the Laplace equation: (Astronomic azimuth—Laplace azimuth) + sine of latitude (astronomic longitude—geodetic longitude) = zero. (See pp. 17 and 18 of the Supplementary Investigation in 1909 of the Figure of the Earth and Isostasy.)

The horizontal directions are reduced to sea level. The correction expressed in seconds is given by

$$\frac{e^2 h \sin 2\alpha \cos^2\phi}{2 \rho \sin 1''}$$

where $e^2 = \frac{(a^2 - b^2)}{a^2}$, h = height of station sighted, ρ = the radius of curvature in a plane normal to the meridian, ϕ = the latitude, and α = the azimuth counted from the south westward.

In the following table are also given the elevations of the telescope of the theodolite above the station mark at each of the primary stations. These elevations enable the reader to judge of the amount of building done and they permit the engineer or surveyor who uses the stations to form an estimate of the probable amount of building required to make any particular line clear.

Station occupied and elevation of instrument above station mark	Number of direction	Object observed	Observed direction reduced to sea level	Final seconds after figure adjustment
			° ′ ″	
Marysville Butte	16	Snow Mountain east	0 00 00.00	00.64
3.73 meters	17	Kent	33 11 28.15	28.82
	18	Lyons	83 06 42.00	42.64
		Mount Helena	305 58 17.33	16.60
		Snow Mountain west	359 25 17.60	18.33
Snow Mountain east	5	Snow Mountain west	0 00 00.00	$\overline{58.54}$
1.58 meters	1	Kent	142 59 12.34	12.30
	2	Lyons	184 37 24.10	24.78
	3	Marysville Butte	245 25 31.85	31.93
	4	Mount Helena	314 30 30.82	31.55
Snow Mountain west		Marysville Butte	0 00 00.00	00.36
		Mount Helena	69 11 10.85	10.50
	20	Snow Mountain east	295 09 07.62	09.10
Mount Helena		Mount Diablo	0 00 $\overline{59.93}$	00.110
		Snow Mountain west	208 09 11.473	11.151
	19	Snow Mountain east	208 37 44.87	42.89
		Marysville Butte	265 31 14.565	14.922
Gazelle astronomic station.	45b	Spur	0 00 00.00	$\overline{59.49}$
1.95 meters	45a	Soda	242 13 53.98	54.50
Kent	21	Bally	0 00 00.02	00.04
1.51 meters	22	Round	29 12 24.35	24.14
	23	Lyons	62 01 55.21	55.69
	24	Marysville Butte	130 43 32.66	32.60
	25	Snow Mountain east	175 05 58.30	58.07
Lyons	15	Round	0 00 $\overline{59.95}$	01.03
1.44 meters	11	Marysville Butte	212 56 26.00	24.84
	12	Snow Mountain east	249 01 61.06	61.25
	13	Kent	274 19 62.35	61.62
	14	Bally	317 17 11.40	12.03
Bally	28	Round	0 00 00.05	00.10
3.06 meters	29	Lyons	42 13 01.56	00.79
	30	Kent	117 14 10.57	10.77
	26	Boliver	282 44 32.07	32.69
		Mears	307 33	04.51
	27	Spur	311 53 12.78	12.69
Round	10	Spur	0 00 $\overline{59.89}$	00.19
1.54 meters	6	Lyons	174 15 49.37	48.30
	7	Kent	235 46 33.31	33.17
	8	Bally	269 20 08.34	08.46
	9	Mears	330 55 18.31	19.12
Mears	34	Boliver	0 00 $\overline{59.87}$	$\overline{59.99}$
1.59 meters	31	Spur	89 50 06.45	06.94
	32	Round	192 05 14.69	13.87
	33	Bally	258 03 15.04	15.24

Station occupied and elevation of instrument above station mark	Number of direction	Object observed	Observed direction reduced to sea level	Final seconds after figure adjustment
			° ′ ″	
Sterling	53	Soda	0 00 00.03	59.90
1.50 meters	54	Spur	60 51 45.03	44.83
	55	Boliver	92 55 29.41	29.09
	51	Onion	258 26 02.01	02.12
	52	Rust	312 26 01.22	01.78
Spur	43	Boliver	0 00 00.10	00.11
1.67 meters	43a	Gazelle astronomic station	50 48 06.40	07.29
	44	Sterling	71 55 04.68	04.85
	45	Soda	95 06 45.90	45.88
	40	Round	269 20 27.85	27.44
	41	Bally	310 33 59.83	59.57
	42	Mears	318 00 44.57	44.19
Boliver	37	Spur	0 00 00.11	00.10
2.54 meters	38	Mears	48 10 40.17	40.06
	39	Bally	101 25 28.71	28.23
	35	Sterling	283 58 38.63	39.25
	36	Soda	305 33 31.28	31.26
Soda	48	Sterling	0 00 00.00	00.25
1.55 meters	49	Onion	57 20 59.99	59.72
	50	Rust	108 37 07.28	08.05
	46	Spur	264 03 19.78	19.66
	46a	Gazelle astronomic station	281 58 40.14	39.63
	47	Boliver	294 30 14.20	14.10
Rust	67	Sterling	0 00 00.00	59.23
1.74 meters	68	Onion	62 50 46.25	46.38
	69	White	101 03 13.56	13.83
	70	Black	137 15 51.99	53.07
	66	Soda	336 11 00.72	00.01
Onion	56	White	0 00 00.00	00.45
1.61 meters	57	Black	31 48 25.91	25.55
	58	Rust	77 51 31.51	31.27
	59	Soda	119 55 48.27	48.10
	60	Sterling	141 00 57.36	57.66
White	63	Black	0 00 00.00	59.63
6.67 meters	64	Rust	49 58 50.86	50.98
	65	Onion	113 55 02.30	01.77
	61	Yellow	243 41 43.82	44.12
	62	Scott	271 11 38.91	39.34
	62a	Fairview	306 34 37.83	37.88
Black	71	Rust	0 00 00.00	58.64
1.53 meters	72	Onion	59 31 56.35	57.05
	73	White	93 48 34.84	35.26
	74	Scott	125 01 47.92	48.89
	75	Fairview	171 08 16.94	16.20
Fairview	80a	White	0 00 00.00	59.48
1.72 meters	81	Scott	23 26 03.35	02.22
	82	Yellow	54 53 23.69	23.34
	83	Roman	81 39 24.54	25.12
	84	Spencer	110 00 45.96	46.59
	80	Black	310 44 55.62	56.40
Scott	78	Black	0 00 00.00	58.70
1.74 meters	79	White	59 58 28.34	28.12
	76	Yellow	189 44 22.86	22.97
	77	Fairview	298 47 25.48	26.91
Yellow	89	White	0 00 00.00	59.77
2.00 meters	85	Roman	178 40 38.63	38.70
	86	Spencer	239 06 47.80	48.00
	87	Fairview	297 46 09.74	09.78
	88	Scott	337 15 48.07	48.00

Station occupied and elevation of instrument above station mark	Number of direction	Object observed	Observed direction reduced to sea level	Final seconds after figure adjustment
			° ′ ″	
Roman	103	Spencer	0 00 00.00	00.19
1.65 meters	104	Fairview	31 04 11.58	11.80
	105	Yellow	65 12 45.72	45.52
	100	Mary	291 34 34.04	33.07
	101	Peterson	321 25 23.53	23.77
	102	Twin	330 41 33.42	33.93
Peterson	112	Twin	0 00 00.00	00.21
1.80 meters	113	Spencer	2 07 17.11	17.02
	114	Willamette south base	12 02 24.57	24.53
	115	Rauch	19 56 37.54	37.26
	116	Roman	35 19 25.25	25.63
	117	Ridge	39 24 39.46	39.22
	118	Mary	81 41 22.60	22.10
	119	Yam	159 38 32.55	32.68
	120	Hult	194 06 36.09	36.48
Mary	110	Spencer	0 00 00.00	59.30
1.68 meters		Willamette south base	1 21	10.01
	111	Roman	45 09 17.07	17.72
	106	Yam	239 47 19.05	18.85
	107	Hult	264 35 34.37	34.88
	108	Peterson	301 21 56.32	57.18
	109	Twin	326 42 41.83	40.72
		Ridge	358 46	44.40
Spencer	98	Peterson	0 00 00.00	00.04
1.77 meters	99	Twin	1 08 19.38	19.94
	90	Fairview	131 12 05.23	04.21
	91	Yellow	197 25 26.30	26.36
	92	Roman	251 46 38.49	37.59
	93	Rauch	270 37 26.91	27.64
	94	Willamette south base	311 51 09.89	10.22
	95	Mary	318 12 01.16	00.36
	96	Ridge	319 15 00.47	01.02
	97	Willamette north base	328 26 41.12	41.57
Rauch	140	Willamette south base	0 00 00.00	59.76
6.22 meters	141	Spencer	38 34 20.22	19.91
	136	Ridge	297 44 13.19	12.67
	137	Willamette north base	323 25 50.80	51.36
	138	Peterson	325 46 09.09	09.68
	139	Twin	335 11 36.46	36.36
Ridge	135	Rauch	0 00 00.00	00.05
2.54 meters	129	Mary	147 11 23.95	23.90
	130	Peterson	227 29 57.53	56.94
	131	Twin	256 41 10.38	10.54
	132	Willamette north base	310 54 60.15	59.92
	133	Spencer	329 27 38.79	39.34
	134	Willamette south base	333 02 17.49	17.59
Willamette north base	151	Rauch	0 00 00.00	00.27
12.84 meters	152	Ridge	105 13 22.03	22.13
	153	Twin	203 26 46.52	46.91
	149	Spencer	312 57 42.01	41.72
	150	Willamette south base	327 11 09.75	09.27
Willamette south base	142	Rauch	0 00 00.00	59.59
12.83 meters	143	Mary	87 30 00.53	02.56
	144	Ridge	90 46 31.35	30.84
	145	Willamette north base	110 37 00.75	00.61
	146	Peterson	137 51 58.15	57.91
	147	Twin	145 36 46.97	46.53
	148	Spencer	259 48 02.20	01.94
Twin	121	Spencer	0 00 00.00	59.69
1.79 meters	122	Willamette south base	16 31 35.58	35.46
	123	Rauch	26 06 25.29	25.71
	124	Willamette north base	37 47 28.18	27.84
	125	Roman	41 19 56.11	55.91
	126	Ridge	65 20 14.14	14.38
	127	Mary	103 46 25.82	26.10
	128	Peterson	176 44 23.07	23.09

Station occupied and elevation of instrument above station mark	Number of direction	Object observed	Observed direction reduced to sea level	Final seconds after figure adjustment
			° ′ ″	
Yam	156	Hult	0 00 00.00	00.19
1.58 meters	157	Peterson	59 23 41.58	41.57
	158	Mary	99 51 59.90	59.90
	154	Barnes	282 51 50.59	50.88
	155	Larch	309 30 21.02	20.54
Hult	161	Yam	0 00 00.00	$\overline{59.92}$
11.13 meters	162	Barnes	69 11 05.28	05.39
	163	Larch	109 25 49.52	50.23
	159	Peterson	273 51 40.67	40.21
	160	Mary	304 40 09.69	09.43
Larch	166	Barnes	0 00 00.00	$\overline{59.89}$
1.65 meters	167	Star	64 13 06.42	06.81
	168	Red	115 22 55.56	55.86
	164	Hult	308 34 23.01	22.88
	165	Yam	328 38 60.20	59.76
Barnes	171	Larch	0 00 00.00	00.66
4.63 meters	172	Hult	88 19 47.53	47.04
	173	Yam	122 00 37.47	37.56
	169	Davis	283 59 30.10	29.94
	170	Star	329 23 21.81	21.71
Star	182	Barnes	0 00 00.00	$\overline{59.65}$
1.29 meters	179	Davis	76 04 01.19	01.64
	180	Red	178 14 18.61	19.10
	181	Larch	274 49 42.99	42.39
Davis	186	Red	0 00 00.00	00.12
1.56 meters	187	Star	38 39 32.25	31.49
	188	Barnes	97 11 41.85	42.23
	183	Toutle	270 11 42.34	42.71
	184	Lam	297 55 51.45	52.07
	185	Len	309 10 20.13	19.39
Red	175	Star	0 00 00.00	$\overline{59.05}$
1.31 meters	176	Davis	39 10 13.92	13.96
	177	Lam	56 47 33.24	33.74
	178	Len	92 49 41.21	41.49
	174	Larch	327 45 08.67	08.81
Lam	201	Len	0 00 00.00	00.11
1.53 meters	202	Red	61 59 39.51	39.26
	203	Davis	162 18 14.19	13.94
	200	Toutle	286 28 44.77	45.14
Len	193	Huck	0 00 00.00	01.00
1.64 meters	194	Bel	43 05 50.04	48.57
	189	Red	177 13 38.18	37.85
	190	Davis	252 44 35.26	35.57
	191	Lam	259 11 54.54	54.88
	192	Toutle	292 18 28.42	28.59
Toutle	199	Davis	0 00 00.00	$\overline{59.25}$
2.93 meters	195	Huck	184 30 34.45	35.49
	196	Bel	213 54 10.59	11.00
	197	Len	258 32 26.86	26.33
	198	Lam	331 54 39.27	39.09
Bel	211	Toutle	0 00 00.00	00.46
1.97 meters	212	Huck	37 44 45.17	44.89
	213	Hal	41 05 38.44	37.67
	214	Rain	55 27 10.83	11.31
	215	Hurst	87 05 27.46	26.51
	210	Len	335 25 30.52	31.60
Huck	205	Hal	0 00 00.00	00.66
1.54 meters	206	Hurst	24 54 18.96	18.84
	207	Bel	110 53 44.10	44.97
	208	Len	185 28 49.40	48.84
	209	Toutle	223 45 30.90	29.38
	204	Rain	338 33 11.51	12.21

Station occupied and elevation of instrument above station mark	Number of direction	Object observed	Observed direction reduced to sea level	Final seconds after figure adjustment
			° ′ ″	
Hal	216	Rain	0 00 00.00	00.34
1.65 meters	217	Hurst	50 18 17.55	17.52
	218	Tacoma north base	58 37 25.30	25.42
	219	Tacoma south base	58 55 27.83	27.92
	220	Pen	77 24 46.84	46.77
	221	Bel	138 07 49.09	49.22
	222	Huck	203 53 12.96	12.36
Rain	228	Hal	0 00 00.00	59.73
3.99 meters	229	Huck	2 26 23.70	23.35
	223	Hurst	262 34 56.62	58.25
	224	Tacoma north base	263 18 48.89	48.93
	225	Tacoma south base	272 24 29.60	29.81
	226	Pen	290 53 00.56	00.32
	227	Bel	332 29 21.85	20.83
Pen	242	Tacoma north base	0 00 00.00	59.79
33.34 meters	238	Hal	233 58 29.41	29.83
	239	Rain	267 26 46.09	45.89
	240	Hurst	321 11 18.53	18.96
	241	Tacoma south base	326 18 32.57	32.13
		Burn	357 26	57.78
Hurst	231	Tacoma north base	0 00 00.00	00.28
32.55 meters	232	Tacoma south base	68 59 18.27	18.42
	233	Pen	79 34 01.52	01.54
	234	Bel	99 04 00.08	01.38
	235	Huck	143 43 59.05	57.71
	236	Hal	145 14 45.09	44.80
	237	Rain	177 31 28.02	27.79
	230	Burn	336 28 08.21	08.32
Tacoma south base	248	Tacoma north base	0 00 00.00	00.00
32.33 meters	243	Pen	112 05 00.83	00.98
	244	Hal	181 15 39.88	40.94
	245	Rain	214 44 45.98	45.23
	246	Hurst	276 23 04.90	04.74
	247	Burn	344 12 37.84	37.54
Tacoma north base	262	Kin	0 00 00.00	00.55
38.28 meters	249	Pen	133 00 22.21	22.07
	250	Tacoma south base	167 13 53.36	53.78
	251	Hal	168 11 32.85	32.25
	252	Rain	192 52 59.32	58.71
	253	Hurst	194 37 40.90	40.56
	254	Burn	302 58 21.69	22.05
	261	Wash	323 57 47.21	47.59
Burn	259	Wash	0 00 00.00	00.14
13.42 meters	260	Kin	76 02 49.34	48.98
	255	Tacoma north base	125 54 43.94	43.63
	256	Pen	133 23 41.08	41.70
	257	Tacoma south base	154 22 53.22	53.04
	258	Hurst	174 02 10.28	10.39
Kin	268	Bos	0 00 00.00	59.92
20.05 meters	263	Tacoma north base	159 37 09.46	08.95
	264	Burn	232 43 35.59	35.88
	265	Wash	274 15 57.55	57.66
	266	Dron	311 31 09.48	09.35
	267	Gull	316 33 18.39	18.69
Wash	269	Smelt	0 00 00.00	59.83
13.34 meters	270	Neill 2	42 32 01.92	02.28
	271	Dron	91 45 21.33	21.40
	272	Gull	99 39 34.94	35.27
	273	Bos	140 17 03.60	03.96
	274	Kin	174 58 06.29	06.00
	275	Tacoma north base	204 17 05.00	04.42
	276	Burn	237 22 55.54	55.45

Station occupied and elevation of instrument above station mark	Number of direction	Object observed	Observed direction reduced to sea level	Final seconds after figure adjustment
			° ′ ″	
Bos	277	Kin	0 00 00.00	59.92
1.84 meters	278	Wash	59 34 55.62	55.69
	279	Dron	96 51 39.04	39.09
	280	Gull	100 01 04.62	04.58
Gull	281	Bos	0 00 00.00	59.82
1.54 meters	282	Kin	36 32 13.92	13.97
	283	Tacoma astronomic station	63 27 46.89	47.50
	284	Wash	98 56 22.77	22.29
Dron	285	Bos	0 00 00.00	59.92
2.56 meters	286	Kin	34 39 30.06	30.24
	287	Wash	94 11 34.19	34.03
	288	Smelt	135 13 54.80	54.63
	289	Neill 2	182 13 53.00	53.24
Smelt	290	Neill 2	0 00 00.00	59.59
3.84 meters	291	Dron	53 37 13.04	13.36
	292	Wash	100 49 31.16	31.25
Neill 2	296	Smelt	0 00 00.00	00.33
1.66 meters	293	Dron	280 37 12.98	12.66
	294	Tacoma astronomic station	304 14 12.70	12.88
	295	Wash	323 21 34.56	34.39
Tacoma astronomic station	297	Neill 2	0 00 00.00	59.81
5.40 meters	298	Gull	40 46 19.32	19.50

CONDITION EQUATIONS.

No.

1. $0=+5.65-(4)+(5)+(19)-(20)$
2. $0=+2.38-(3)+(5)+(16)-(20)$
3. $0=+0.02-(1)+(3)-(16)+(17)-(24)+(25)$
4. $0=+0.91-(1)+(2)-(12)+(13)-(23)+(25)$
5. $0=+0.14-(11)+(13)-(17)+(18)-(23)+(24)$
6. $0=-2.78-(13)+(14)-(21)+(23)-(29)+(30)$
7. $0=-0.82-(6)+(8)-(14)+(15)-(28)+(29)$
8. $0=-0.17-(7)+(8)-(21)+(22)-(28)+(30)$
9. $0=-0.47-(8)+(10)-(27)+(28)-(40)+(41)$
10. $0=+1.79-(9)+(10)-(31)+(32)-(40)+(42)$
11. $0=+0.91-(26)+(27)-(37)+(39)-(41)+(43)$
12. $0=-0.66+(31)-(34)-(37)+(38)-(42)+(43)$
13. $0=+0.59-(35)+(37)-(43)+(44)-(54)+(55)$
14. $0=+2.33-(43a)+(45)-(45a)+(45b)-(46)+(46a)$
15. $0=-0.11-(44)+(45)-(46)+(48)-(53)+(54)$
16. $0=+0.49-(35)+(36)-(47)+(48)-(53)+(55)$
17. $0=+0.23-(48)+(50)-(52)+(53)-(66)+(67)$
18. $0=-1.95-(49)+(50)-(66)+(68)-(58)+(59)$
19. $0=-1.89-(51)+(52)-(67)+(68)-(58)+(60)$
20. $0=-3.13-(57)+(58)-(68)+(70)-(71)+(72)$
21. $0=+1.25-(56)+(57)-(63)+(65)-(72)+(73)$
22. $0=-3.09-(63)+(64)-(69)+(70)-(71)+(73)$
23. $0=+2.88-(62a)+(63)-(73)+(75)-(80)+(80a)$
24. $0=+6.35-(74)+(75)-(77)+(78)-(80)+(81)$
25. $0=+2.64-(62)+(62a)-(77)+(79)-(80a)+(81)$
26. $0=-0.30-(61)+(62)+(76)-(79)-(88)+(89)$
27. $0=-2.00-(76)+(77)-(81)+(82)-(87)+(88)$
28. $0=-1.89-(82)+(84)-(86)+(87)-(90)+(91)$
29. $0=-0.47-(82)+(83)-(85)+(87)-(104)+(105)$
30. $0=+1.22-(85)+(86)-(91)+(92)-(103)+(105)$
31. $0=-2.61-(92)+(95)-(100)+(103)-(110)+(111)$
32. $0=-1.36-(92)+(98)-(101)+(103)-(113)+(116)$
33. $0=-0.12-(100)+(101)-(108)+(111)-(116)+(118)$
34. $0=+2.94-(108)+(109)-(112)+(118)-(127)+(128)$
35. $0=-0.66-(101)+(102)-(112)+(116)-(125)+(128)$
36. $0=-0.55-(98)+(99)-(112)+(113)-(121)+(128)$
37. $0=-0.95-(96)+(99)-(121)+(126)-(131)+(133)$
38. $0=-0.08-(112)+(117)-(126)+(128)-(130)+(131)$

No.

39. 0 = +0.47 − (93) + (96) − (133) + (135) − (136) + (141)
40. 0 = −1.79 − (115) + (117) − (130) + (135) − (136) + (138)
41. 0 = −0.14 − (123) + (126) − (131) + (135) − (136) + (139)
42. 0 = +0.90 − (114) + (115) − (138) + (140) − (142) + (146)
43. 0 = +0.62 − (93) + (94) − (140) + (141) + (142) − (148)
44. 0 = −0.13 − (134) + (135) − (136) + (140) − (142) + (144)
45. 0 = −0.36 − (122) + (123) − (139) + (140) − (142) + (147)
46. 0 = −1.28 − (132) + (134) − (144) + (145) − (150) + (152)
47. 0 = −0.22 − (137) + (140) − (142) + (145) − (150) + (151)
48. 0 = +0.19 − (94) + (97) − (145) + (148) − (149) + (150)
49. 0 = +1.39 − (122) + (124) − (145) + (147) + (150) − (153)
50. 0 = −1.70 − (106) + (108) − (118) + (119) − (157) + (158)
51. 0 = −0.70 − (106) + (107) − (156) + (158) − (160) + (161)
52. 0 = −0.44 − (119) + (120) − (156) + (157) − (159) + (161)
53. 0 = −0.67 − (154) + (156) − (161) + (162) − (172) + (173)
54. 0 = +1.01 − (154) + (155) − (165) + (166) − (171) + (173)
55. 0 = +0.53 − (162) + (163) − (164) + (166) − (171) + (172)
56. 0 = −1.51 − (166) + (167) − (170) + (171) − (181) + (182)
57. 0 = −2.00 − (169) + (170) + (179) − (182) − (187) + (188)
58. 0 = +2.27 − (167) + (168) − (174) + (175) − (180) + (181)
59. 0 = −0.15 − (175) + (176) − (179) + (180) − (186) + (187)
60. 0 = −1.74 − (176) + (178) − (185) + (186) − (189) + (190)
61. 0 = +0.03 − (176) + (177) − (184) + (186) − (202) + (203)
62. 0 = +1.69 − (184) + (185) − (190) + (191) − (201) + (203)
63. 0 = −0.30 − (183) + (184) − (198) + (199) + (200) − (203)
64. 0 = +0.08 − (191) + (192) − (197) + (198) − (200) + (201)
65. 0 = +1.70 − (192) + (193) − (195) + (197) − (208) + (209)
66. 0 = +3.20 − (192) + (194) − (196) + (197) − (210) + (211)
67. 0 = +5.26 − (193) + (194) − (207) + (208) − (210) + (212)
68. 0 = +1.01 − (205) + (207) − (212) + (213) − (221) + (222)
69. 0 = −0.82 − (204) + (205) + (216) − (222) − (228) + (229)
70. 0 = −1.79 − (213) + (214) − (216) + (221) − (227) + (228)
71. 0 = +1.70 − (204) + (206) − (223) + (229) − (235) + (237)
72. 0 = +5.62 − (214) + (215) − (223) + (227) − (234) + (237)
73. 0 = +2.22 − (216) + (217) − (223) + (228) − (236) + (237)
74. 0 = +0.34 − (217) + (220) − (233) + (236) − (238) + (240)
75. 0 = +1.49 − (223) + (226) − (233) + (237) − (239) + (240)
76. 0 = +0.11 − (219) + (220) − (238) + (241) − (243) + (244)
77. 0 = +1.59 − (225) + (226) − (239) + (241) − (243) + (245)
78. 0 = +1.31 − (232) + (233) − (240) + (241) − (243) + (246)
79. 0 = +2.11 − (218) + (219) − (244) + (248) − (250) + (251)
80. 0 = +0.11 − (224) + (225) − (245) + (248) − (250) + (252)
81. 0 = +0.73 − (231) + (232) − (246) + (248) − (250) + (253)
82. 0 = −0.94 − (241) + (242) + (243) − (248) − (249) + (250)
83. 0 = −1.29 − (230) + (231) − (253) + (254) − (255) + (258)
84. 0 = −0.37 − (247) + (248) − (250) + (254) − (255) + (257)
85. 0 = −1.04 − (254) + (255) − (260) + (262) − (263) + (264)
86. 0 = −0.50 − (261) + (262) − (263) + (265) − (274) + (275)
87. 0 = +0.48 − (259) + (260) − (264) + (265) − (274) + (276)
88. 0 = +0.69 − (265) + (268) − (273) + (274) − (277) + (278)
89. 0 = +0.10 − (267) + (268) − (277) + (280) − (281) + (282)
90. 0 = +0.37 − (272) + (273) − (278) + (280) − (281) + (284)
91. 0 = −0.44 − (266) + (268) − (277) + (279) − (285) + (286)
92. 0 = −0.19 − (271) + (273) − (278) + (279) − (285) + (287)
93. 0 = +0.01 − (269) + (271) − (287) + (288) − (291) + (292)
94. 0 = −1.53 − (269) + (270) − (290) + (292) − (295) + (296)
95. 0 = −1.80 − (288) + (289) − (290) + (291) − (293) + (296)
96. 0 = −0.33 − (270) + (272) + (283) − (284) − (294) + (295) + (297) − (298)
97. 0 = −641.3 + 207.1 (16) − 254.9 (19) + 3.0 (20)
98. 0 = +6.5 + 2.83 (1) − 2.37 (2) − 0.46 (3) + 1.15 (11) − 4.46 (12) + 3.31 (13) + 3.22 (16) − 4.99 (17) + 1.77 (18)
99. 0 = −0.4 − 0.19 (6) − 3.17 (7) + 3.36 (8) + 2.26 (13) − 4.54 (14) + 2.28 (15) + 2.65 (21) − 3.77 (22) + 1.12 (23)
100. 0 = +18.7 + 2.76 (8) − 6.55 (9) + 3.79 (10) − 27.80 (31) + 1.62 (32) + 26.18 (33) + 1.85 (40) − 43.92 (41) + 42.07 (42)
101. 0 = −11.6 + 27.80 (31) − 32.36 (33) + 4.56 (34) + 1.88 (37) − 8.01 (38) + 6.13 (39) + 43.92 (41) − 46.26 (42) + 2.34 (43)
102. 0 = −2.6 + 5.32 (35) − 6.83 (36) + 1.51 (37) − 0.19 (43) − 4.91 (44) + 5.10 (45) + 1.28 (53) − 1.17 (54) − 0.11 (55)
103. 0 = −1.4 − 0.43 (51) − 1.92 (52) + 2.35 (53) + 2.33 (58) − 7.79 (59) + 5.46 (60) + 4.65 (66) − 4.77 (67) + 0.12 (68)
104. 0 = −3.8 + 2.95 (56) − 3.40 (57) + 0.45 (58) + 2.70 (68) − 5.58 (69) + 2.88 (70) − 0.14 (71) − 3.09 (72) + 3.23 (73)
105. 0 = +6.0 + 2.92 (62) − 2.96 (62a) + 3.47 (73) − 5.50 (74) + 2.03 (75) + 0.66 (80) − 4.85 (80a) + 4.19 (81) + 0.04 (63)
106. 0 = +3.5 − 4.05 (61) + 7.01 (62) − 2.96 (62a) − 4.85 (80a) + 8.29 (81) − 3.44 (82) − 2.56 (87) + 7.58 (88) − 5.02 (89)
107. 0 = −7.9 − 4.17 (82) + 8.07 (83) − 3.90 (84) − 1.19 (85) + 2.47 (86) − 1.28 (87) − 0.93 (90) + 2.44 (91) − 1.51 (92) − 3.49 (103) + 6.59 (104) − 3.10 (105)
108. 0 = −1.1 − 0.92 (92) + 3.28 (95) − 2.36 (98) − 3.67 (100) + 6.31 (101) − 2.64 (103) − 1.28 (108) + 3.37 (110) − 2.09 (111) − 3.22 (113) + 5.23 (116) − 2.01 (118)
109. 0 = −68.8 − 0.74 (92) − 105.90 (98) + 106.64 (99) + 12.90 (101) − 16.65 (102) + 3.75 (103) + 53.87 (112) − 56.84 (113) + 2.97 (116)
110. 0 = +78.7 − 2.26 (95) + 105.90 (98) − 103.64 (99) − 4.45 (108) + 7.66 (109) − 3.21 (110) − 56.43 (112) + 56.74 (113) − 0.31 (118)
111. 0 = −228.6 − 213.7 (95) + 216.0 (96) − 2.3 (99) − 1.0 (121) + 7.0 (126) − 6.0 (127) + 102.2 (129) − 3.4 (131) − 98.8 (133)
112. 0 = +1.3 + 2.56 (112) − 6.23 (117) + 3.67 (118) + 6.84 (126) − 6.01 (127) − 0.83 (128) + 2.01 (129) + 1.35 (130) − 3.36 (131)

No.

113. 0=+10.9+3.24(112)−5.80(115)+2.56(117)+3.77(130)−3.27(131)−0.50(135)+2.75(136)−12.68(138)+9.93(139)

114. 0=+1.3−1.84 (93)+1.86 (96)−0.02 (98)−6.55 (113)+12.50 (115)−5.95 (117)+1.93 (130)+3.57 (133)−5.50 (135)

115. 0=−319.8+106.34 (94)−108.15 (95)+1.81 (99)+7.10 (121)−10.25 (122)+3.15 (127)+86.15 (143)+3.05 (147) −89.20 (148)

116. 0=+219[illegible]−4.07 (114)+7.74 (117)−3.67 (118)+48.20 (129)−1.35 (130)−46.85 (134)−83.65 (143)+85.61 (144) −1.96 (146)

117. 0=−20.3−14.34 (94)+16.23 (96)−1.89 (98)−12.03 (113)+16.10 (114)−4.07 (117)+0.59 (130)+33.70 (133) −34.29 (134)

118. 0=+3.4+9.87 (112)−25.03 (114)+15.16 (115)+12.48 (122)−8.74 (123)−3.74 (128)+12.68 (138)−17.24 (139) +4.56 (140)−2.33 (142)−13.16 (146)+15.49 (147)

119. 0=+7.8−2.40 (93)+9.47 (94)−7.07 (97)−2.84 (137)+5.48 (140)−2.64 (141)−8.31 (149)+11.58 (150)−3.27 (151)

120. 0=+26.5+16.23 (94)−29.24 (96)+13.01 (97)+6.27 (132)−39.97 (133)+33.70 (134)+5.84 (144)−2.31 (145) −3.53 (148)+8.31 (149)−5.97 (150)−2.34 (152)

121. 0=−2.8−5.41 (122)+10.17 (123)−4.76 (124)−7.28 (137)+10.12 (139)−2.84 (140)+0.79 (142)+2.22 (145) −3.01 (147)

122. 0=−1.9−4.56 (106)+7.38 (107)−2.82 (108)−0.45 (118)+3.52 (119)−3.07 (120)−1.25 (156)+3.72 (157)−2.47 (158) −3.53 (159)+4.99 (160)−1.46 (161)

123. 0=+10.6−4.20 (154)+5.94 (155)−1.74 (156)−0.80 (161)+3.29 (162)−2.49 (163)−5.76 (164)+9.22 (165) −3.46 (166)−0.06 (171)+3.22 (172)−3.16 (173)

124. 0=+11.9−1.02 (166)+2.72 (167)−1.70 (168)−2.08 (169)+5.64 (170)−3.56 (171)−3.34 (174)+5.92 (175) −2.58 (176)−2.63 (186)+3.92 (187)−1.29 (188)

125. 0=+10.4−6.63 (176)+9.52 (177)−2.89 (178)−9.47 (184)+10.59 (185)−1.12 (186)−0.30 (189)+18.61 (190) −18.31 (191)

126. 0=+18.8+4.00 (183)−14.59 (184)+10.59 (185)+18.61 (190)−21.84 (191)+3.23 (192)+0.63 (197)−4.57 (198) +3.94 (199)

127. 0=−6.8−0.86 (192)+3.11 (193)−2.25 (194)−3.74 (195)+5.87 (196)−2.13 (197)−0.58 (207)+3.25 (208) −2.67 (209)−4.60 (210)+7.32 (211)−2.72 (212)

128. 0=−21.2+5.36 (204)−4.56 (205)−0.80 (207)+36.00 (212)−44.22 (213)+8.22 (214)+4.04 (227)−53.45 (228) +49.41 (229)

129. 0=−91.2−5.36 (204)+9.89 (205)−4.53 (206)+0.27 (223)+49.14 (228)−49.41 (229)−79.73 (235)+83.06 (236) −3.33 (237)

130. 0=+4.6−4.78 (212)+6.59 (214)−1.81 (215)+0.37 (223)+3.65 (227)−4.02 (229)−2.13 (234)+5.28 (235)−3.15 (237)

131. 0=+11.2−1.75 (216)+5.86 (217)−4.11 (220)−3.91 (223)+4.71 (226)−0.80 (228)−0.95 (233)+4.28 (236)−3.33 (237) −3.18 (238)+4.72 (239)−1.54 (240)

132. 0=−4.1−12.16 (223)+18.46 (225)−6.30 (226)−11.99 (232)+11.28 (233)+0.71 (237)−1.27 (239)+23.50 (240) −22.23 (241)

133. 0=−22.2−13.89 (217)+20.19 (219)−6.30 (220)−10.77 (232)+11.28 (233)−0.51 (236)+0.09 (238)+23.50 (240) −23.59 (241)

134. 0=−118.3−401.2 (218)+407.5 (219)−6.3 (220)+0.1 (238)+3.1 (241)−3.2 (242)−3.1 (249)+128.6 (250) −125.5 (251)

135. 0=−15.2+0.81 (231)−12.09 (232)+11.28 (233)+23.50 (240)−26.66 (241)+3.16 (242)+3.10 (249)−7.16 (250) +4.06 (253)

136. 0=+287.5−164.9 (223)+178.06 (224)−13.16 (225)−0.81 (231)+0.10 (232)+0.71 (237)−1.14 (245)+1.38 (246) −0.24 (248)−4.38 (250)+73.49 (252)−69.11 (253)

137. 0=−85.5−3.16 (241)+3.16 (242)+0.85 (243)−7.45 (247)+6.60 (248)−47.27 (249)+47.27 (254)−59.42 (255) +63.30 (256)−3.88 (257)

138. 0=+26.6+0.09 (230)+11.19 (232)−11.28 (233)−23.50 (240)+23.50 (241)+3.49 (243)−3.49 (247)−8.98 (256) +14.88 (257)−5.90 (258)

139. 0=+2.5−5.49 (254)−1.78 (255)−0.52 (259)+2.30 (260)+8.38 (261)−2.89 (262)−0.64 (263)+3.02 (264)−2.38 (265) −3.75 (274)+6.98 (275)−3.23 (276)

140. 0=−5.0−2.32 (265)+4.54 (267)−2.22 (268)−2.45 (272)+5.49 (273)−3.04 (274)−1.24 (277)+371 (278)−2.47 (280) −2.84 (281)+3.94 (282)−1.10 (284)

141. 0=−3.2−2.77 (265)+4.63 (266)−1.86 (268)−1.86 (271)+4.90 (273)−3.04 (274)−1.24 (277)+4.01 (278)−2.77 (279) −3.04 (285)+4.28 (286)−1.24 (287)

142. 0=−1.4−2.30 (269)+4.12 (270)−1.82 (271)−2.42 (287)+4.38 (288)−1.96 (289)−1.55 (290)+3.50 (291)−1.95 (292) −2.28 (293)+5.11 (295)−2.83 (296)

143. 0=−5.7−0.46 (1)+1.42 (3)−0.96 (5)+0.19 (6)−0.21 (8)+0.02 (10)−1.15 (11)+1.15 (13)+2.28 (14)−2.28 (15) +1.77 (17)−1.77 (18)+0.99 (20)+1.12 (21)−1.12 (23)−2.15 (24)+2.15 (25)+3.78 (26)−3.78 (27)−0.56 (29) +0.56 (30)+5.32 (35)−5.32 (36)+0.42 (37)−0.42 (39)−2.40 (40)+2.40 (41)−0.19 (43)+0.19 (45)−3.58 (46) +3.58 (47)−0.71 (48)+0.71 (50)+1.53 (51)−1.53 (52)+0.11 (53)−0.11 (55)+0.45 (56)−1.51 (58)+1.06 (60) +1.08 (61)−1.08 (62a)−1.03 (64)+1.03 (65)−4.77 (66)+4.77 (67)+2.88 (69)−2.88 (70)+0.14 (71)+0.33 (73) −0.47 (75)−1.81 (80)+1.81 (80a)+1.47 (82)−1.47 (84)+1.19 (85)−1.19 (86)−1.11 (87)+1.11 (89)−0.93 (90) +0.93 (91)+1.32 (93)−1.32 (97)+0.83 (100)−1.80 (103)+0.97 (105)+3.21 (109)−5.31 (110)+2.10 (111)+3.24 (121) −2.72 (124)−0.52 (127)+2.28 (137)−2.84 (140)+0.56 (141)+0.79 (142)−0.79 (145)−0.75 (149)+0.75 (153)

144. 0=+10.9+1.32 (93)−2.26 (95)−1.32 (97)+2.26 (99)−1.14 (106)+1.14 (108)+3.21 (109)−3.21 (110)+0.31 (112) −0.31 (118)−3.07 (119)+3.07 (120)+2.72 (121)−2.72 (124)−0.65 (127)+0.65 (128)+2.28 (137)−2.84 (140) +0.56 (141)+0.79 (142)−0.79 (145)−0.75 (149)+0.75 (153)−0.48 (154)+0.48 (156)+2.47 (157)−2.47 (158) +0.14 (159)−0.14 (161)−2.49 (162)+2.49 (163)+1.68 (164)−2.70 (166)+1.02 (167)−2.08 (169)+2.08 (170) +3.16 (172)−3.16 (173)+2.58 (175)−4.13 (176)+1.55 (178)+0.45 (179)−0.45 (180)+0.18 (181)−0.18 (182) −2.60 (183)+2.60 (185)+1.29 (187)−1.29 (188)+0.54 (189)−0.54 (190)−2.25 (193)+2.25 (194)−0.61 (195) +0.18 (197)+0.43 (199)−2.01 (204)+2.01 (206)+2.67 (208)−2.67 (209)+1.10 (210)−2.91 (212)+1.81 (215) −4.28 (223)+3.91 (226)+0.37 (229)−0.81 (231)+0.81 (232)+2.13 (234)−2.13 (235)+1.54 (239)−4.16 (240) +2.62 (242)+0.24 (246)−0.24 (248)+1.14 (249)−1.14 (253)

145. 0=−5.55−(6)+(10)−(11)+(15)+(18)−(40)+(43a)

146. 0=−5.92+(45a)−(45b)−(46a)+(50)−(66)+(70)−(71)+(75)−(80)+(84)−(90)+(94)

147. 0=−0.10−(94)+(98)−(113)+(120)−(159)+(163)−(164)+(168)−(174)+(178)−(189)+(194)−(210)+(213)+(220) −(221)−(238)+(242)−(249)+(262)−(263)+(268)−(277)+(280)−(281)+(283)

ACCURACY AS INDICATED BY CORRECTIONS TO OBSERVED DIRECTIONS.

The corrections to observed directions resulting from the figure adjustments indicated by the preceding observation equations are as follows:

Table of corrections to observed directions.

Number of direction	Correction to direction	Number of direction	Correction to direction	Number of direction	Correction to direction	Number of direction	Correction to direction
1	−0.040	52	+0.556	105	−0.197	160	−0.266
2	+0.681	53	−0.134	106	−0.203	161	−0.084
3	+0.085	54	−0.202	107	+0.506	162	+0.108
4	+0.736	55	−0.327	108	+0.858	163	+0.708
5	−1.461	56	+0.452	109	−1.110	164	−0.130
6	−1.075	57	−0.355	110	−0.703	165	−0.443
7	−0.142	58	−0.236	111	+0.653	166	−0.109
8	+0.114	59	−0.167	112	+0.214	167	+0.388
9	+0.807	60	+0.306	113	−0.086	168	+0.294
10	+0.297	61	+0.299	114	−0.033	169	−0.160
11	−1.160	62	+0.431	115	−0.280	170	−0.100
12	+0.187	62a	+0.051	116	+0.384	171	+0.663
13	−0.729	63	−0.369	117	−0.237	172	−0.491
14	+0.626	64	+0.123	118	−0.494	173	+0.088
15	+1.077	65	−0.535	119	+0.137	174	+0.135
16	+0.643	66	−0.707	120	+0.396	175	−0.954
17	+0.674	67	−0.771	121	−0.311	176	+0.038
18	+0.643	68	+0.132	122	−0.118	177	+0.499
19	−1.976	69	+0.267	123	+0.415	178	+0.282
20	+1.478	70	+1.079	124	−0.340	179	+0.453
21	+0.023	71	−1.363	125	−0.195	180	+0.490
22	−0.210	72	+0.701	126	+0.243	181	−0.597
23	+0.481	73	+0.424	127	+0.285	182	−0.346
24	−0.059	74	+0.974	128	+0.021	183	+0.370
25	−0.235	75	−0.736	129	−0.050	184	+0.616
26	+0.618	76	+0.105	130	−0.591	185	−0.740
27	−0.094	77	+1.422	131	+0.162	186	+0.124
28	+0.051	78	−1.304	132	−0.231	187	−0.755
29	−0.770	79	−0.224	133	+0.554	188	+0.385
30	+0.196	80	+0.782	134	+0.103	189	−0.328
31	+0.494	80a	−0.518	135	+0.053	190	+0.306
32	−0.816	81	−1.133	136	−0.514	191	+0.331
33	+0.200	82	−0.344	137	+0.562	192	+0.167
34	+0.122	83	+0.582	138	+0.589	193	+0.994
35	+0.617	84	+0.626	139	−0.095	194	−1.470
36	−0.024	85	+0.070	140	−0.237	195	+1.042
37	−0.009	86	+0.196	141	−0.305	196	+0.414
38	−0.106	87	+0.035	142	−0.415	197	−0.526
39	−0.478	88	−0.070	143	+2.026	198	−0.181
40	−0.406	89	−0.231	144	−0.513	199	−0.748
41	−0.261	90	−1.016	145	−0.144	200	+0.376
42	−0.381	91	+0.060	146	−0.243	201	+0.115
43	+0.008	92	−0.898	147	−0.447	202	−0.247
43a	+0.891	93	+0.729	148	−0.264	203	−0.245
44	+0.169	94	+0.335	149	−0.291	204	+0.696
45	−0.020	95	−0.800	150	−0.475	205	+0.657
45a	+0.514	96	+0.550	151	+0.273	206	−0.126
45b	−0.514	97	+0.447	152	+0.102	207	+0.865
46	−0.123	98	+0.038	153	+0.391	208	−0.566
46a	−0.514	99	+0.555	154	+0.293	209	−1.525
47	−0.100	100	−0.966	155	−0.479	210	+1.079
48	+0.244	101	+0.237	156	+0.192	211	+0.457
49	−0.275	102	+0.511	157	−0.007	212	−0.285
50	+0.767	103	+0.191	158	+0.001	213	−0.777
51	+0.109	104	+0.224	159	−0.465	214	+0.477

Table of corrections to observed directions—Continued.

Number of direction	Correction to direction	Number of direction	Correction to direction	Number of direction	Correction to direction	Number of direction	Correction to direction
215	−0.952	240	+0.435	260	−0.365	280	−0.036
216	+0.342	241	−0.440	261	+0.376	281	−0.183
217	−0.027	242	−0.213	262	+0.550	282	+0.050
218	+0.123	243	+0.150	263	−0.503	283	+0.610
219	+0.095	244	+1.064	264	+0.294	284	−0.478
220	−0.069	245	−0.753	265	+0.115	285	−0.082
221	+0.132	246	−0.161	266	−0.128	286	+0.177
222	−0.595	247	−0.300	267	+0.300	287	−0.166
223	+1.634	248	0.000	268	−0.078	288	−0.173
224	+0.044	249	−0.146	269	−0.167	289	+0.244
225	+0.210	250	+0.416	270	+0.360	290	−0.409
226	−0.237	251	−0.603	271	+0.068	291	+0.324
227	−1.022	252	−0.613	272	+0.331	292	+0.086
228	−0.276	253	−0.339	273	+0.361	293	−0.325
229	−0.353	254	+0.358	274	−0.287	294	+0.182
230	+0.113	255	−0.314	275	−0.579	295	−0.173
231	+0.282	256	+0.619	276	−0.086	296	+0.325
232	+0.146	257	−0.187	277	−0.082	297	−0.182
233	+0.022	258	+0.110	278	+0.068	298	+0.182
234	+1.303	259	+0.136	279	+0.050		
235	−1.341						
236	−0.291						
237	−0.233						
238	+0.419						
239	−0.201						

The maximum correction to an observed direction on the California-Washington arc is 2″.03, the correction at station Willamette south base on station Mary.

The probable error of an observed direction is

$$d = 0.674\sqrt{\frac{\Sigma v^2}{c}}$$

in which Σv^2 is the sum of the squares of the corrections to directions, and c is the number of conditions.

The probable error of an observed direction for this arc is ±0″.53. Referring to the table on pages 63 and 64 of Special Publication No. 11, where the 63 sections of primary triangulation in the United States have been arranged according to accuracy, this triangulation would belong in the less accurate portion between numbers 52 and 53.

ACCURACY AS INDICATED BY CORRECTIONS TO ANGLES AND CLOSURES OF TRIANGLES.

The correction to each angle is the algebraic sum of the corrections to two directions. In order to make it possible to study the corrections to the separate angles they are shown in the following table for every triangle in the primary scheme. There are also shown the errors of closures of the triangles, the corrected spherical angles and the spherical excess for each triangle. The plus sign prefixed to the error of closure of a triangle indicates that the sum of the angles is less than 180° plus the spherical excess. The spherical excess is a convenient indication of the size of the triangle, since it is proportional to the area.

Table of triangles.

Station	Correction to angles from figure adjustment	Error of closure of triangle	Corrected spherical angles	Spherical excess
	″	″	° ′ ″	″
Snow Mountain west	−0.71		69 11 10.14	
Marysville Butte	+1.32		53 26 61.73	15.64
Mount Helena			57 21 63.77	
Snow Mountain east	+0.65		69 04 59.62	
Marysville Butte	+0.64	+3.27	54 01 44.04	15.69
Mount Helena	+1.98		56 53 32.03	
Snow Mountain east	−1.54		114 34 26.61	
Marysville Butte	+0.64	−2.38	0 34 42.31	0.18
Snow Mountain west	−1.48		64 50 51.26	
Snow Mountain east	−2.19		45 29 26.99	
Mount Helena	−1.98	−5.65	0 28 31.74	0.13
Snow Mountain west	−1.48		134 02 01.40	
Kent	−0.18		44 22 25.46	
Marysville Butte	+0.03	−0.02	33 11 28.18	13.28
Snow Mountain east	+0.13		102 26 19.64	
Lyons	+1.35		36 05 36.41	
Marysville Butte	0.00	+0.75	83 06 42.00	25.56
Snow Mountain east	−0.60		60 48 07.15	
Lyons	+0.43		61 23 36.78	
Marysville Butte	−0.03	−0.14	49 55 13.82	27.51
Kent	−0.54		68 41 36.91	
Lyons	−0.92		25 17 60.37	
Snow Mountain east	+0.72	−0.91	41 38 12.48	15.23
Kent	−0.71		113 03 62.38	
Bally	+0.97		75 01 09.98	
Lyons	+1.35	+2.78	42 57 10.40	16.03
Kent	+0.46		62 01 55.65	
Round	+0.93		61 30 44.87	
Lyons	+1.81	+3.43	85 39 59.41	15.83
Kent	+0.69		32 49 31.55	
Round	+1.19		95 04 20.16	
Lyons	+0.45	+0.82	42 42 49.00	9.85
Bally	−0.82		42 12 60.69	
Round	+0.26		33 33 35.29	
Kent	−0.23	+0.17	29 12 24.10	10.05
Bally	+0.14		117 14 10.66	
Mears	+1.02		65 57 61.37	
Round	+0.69		61 35 10.66	7.62
Bally			52 26 55.59	
Spur	+0.15		41 13 32.13	
Round	+0.18	+0.47	90 39 54.73	11.27
Bally	+0.14		48 06 47.41	
Spur	+0.03		48 40 16.75	
Round	−0.51	−1.79	29 04 41.07	4.75
Mears	−1.31		102 15 06.93	
Spur	−0.12		7 26 44.62	
Bally			4 20 08.18	1.10
Mears	−0.29		168 13 08.30	
Boliver	−0.10		48 10 39.96	
Spur	+0.39	+0.66	41 59 15.92	2.83
Mears	+0.37		89 50 06.95	

Table of triangles—Continued.

Station	Correction to angles from figure adjustment	Error of closure of triangle	Corrected spherical angles	Spherical excess
	″	″	° ′ ″	″
Boliver	−0.47		101 25 28.13	
Spur	+0.27	−0.91	49 25 60.54	8.67
Bally	−0.71		29 08 40.00	
Boliver	−0.37		53 14 48.17	
Mears	−0.08		101 56 44.75	4.74
Bally			24 48 31.82	
Gazelle astronomic station	−1.03		117 46 04.99	
Soda	−0.39	−2.33	17 55 19.97	3.55
Spur	−0.91		44 18 38.59	
Soda	+0.02		30 26 54.44	
Spur	−0.03	+0.01	95 06 45.77	9.06
Boliver	+0.02		54 26 28.85	
Sterling	−0.07		60 51 44.93	
Soda	+0.37	+0.11	95 56 40.59	6.55
Spur	−0.19		23 11 41.03	
Sterling	−0.19		92 55 29.19	
Soda	+0.34	−0.49	65 29 46.14	7.34
Boliver	−0.64		21 34 52.01	
Sterling	−0.12		32 03 44.26	
Spur	+0.16	−0.59	71 55 04.74	9.85
Boliver	−0.63		76 01 20.85	
Rust	−0.06		23 48 59.22	
Soda	+0.52	−0.23	108 37 07.80	5.14
Sterling	−0.69		47 33 58.12	
Onion	+0.07		42 04 16.83	
Rust	+0.84	+1.95	86 39 46.37	11.53
Soda	+1.04		51 16 08.33	
Onion	+0.54		63 09 26.39	
Rust	+0.90	+1.89	62 50 47.15	13.20
Sterling	+0.45		53 59 59.66	
Onion	+0.47		21 05 09.56	
Soda	−0.52	−0.29	57 20 59.47	6.81
Sterling	−0.24		101 33 57.78	
Black	+2.06		59 31 58.41	
Rust	+0.95	+3.13	74 25 06.69	10.82
Onion	+0.12		46 03 05.72	
White	+0.49		49 58 51.35	
Black	+1.79	+3.09	93 48 36.63	7.22
Rust	+0.81		36 12 39.24	
White	−0.16		113 55 02.14	
Black	−0.28	−1.25	34 16 38.21	5.45
Onion	−0.81		31 48 25.10	
White	−0.66		63 56 10.78	
Rust	+0.14	−1.21	38 12 27.45	9.05
Onion	−0.69		77 51 30.82	
Scott	+1.08		59 58 29.42	
Black	+0.55	+0.83	31 13 13.63	3.34
White	−0.80		88 48 20.29	
Fairview	−1.30		49 15 03.08	
Black	−1.16	−2.88	77 19 40.94	5.77
White	−0.42		53 25 21.75	

Table of triangles—Continued.

Station	Correction to angles from figure adjustment	Error of closure of triangle	Corrected spherical angles	Spherical excess
	″	″	° ′ ″	″
Fairview	−1.91		72 41 05.82	
Black	−1.71	−6.35	46 06 27.31	4.92
Scott	−2.73		61 12 31.79	
Fairview	−0.61		23 26 02.74	
White	−0.38	−2.64	35 22 58.54	2.49
Scott	−1.65		121 11 01.21	
Yellow	−0.11		39 29 38.22	
Fairview	+0.79	+2.00	31 27 21.13	3.29
Scott	+1.32		109 03 03.94	
Yellow	−0.27		62 13 49.99	
Fairview	+0.17	−0.34	54 53 23.86	7.62
White	−0.24		62 52 53.77	
Yellow	−0.16		22 44 11.77	
Scott	+0.33	+0.30	129 45 54.85	1.84
White	+0.13		27 29 55.22	
Spencer	+1.08		66 13 22.15	
Fairview	+0.97	+1.89	55 07 23.24	7.17
Yellow	−0.16		58 39 21.78	
Roman	+0.03		31 04 11.61	
Spencer	+0.12	+0.20	120 34 33.38	6.46
Fairview	+0.05		28 21 21.47	
Roman	−0.39		65 12 45.33	
Spencer	−0.96	−1.22	54 21 11.23	5.86
Yellow	+0.13		60 26 09.30	
Roman	−0.42		34 08 33.72	
Fairview	+0.93	+0.47	26 46 01.78	6.57
Yellow	−0.04		119 05 31.07	
Mary	+1.35		45 09 18.42	
Spencer	+0.10	+2.61	66 25 22.77	8.31
Roman	+1.16		68 25 27.12	
Peterson	−0.41		79 34 05.08	
Spencer	+0.84	−1.13	41 47 59.68	6.88
Mary	−1.56		58 38 02.12	
Peterson	+0.47		33 12 08.61	
Spencer	+0.94	+1.36	108 13 22.45	7.48
Roman	−0.05		38 34 36.42	
Peterson	−0.88		46 21 56.47	
Roman	+1.20	+0.12	29 50 50.69	7.71
Mary	−0.20		103 47 20.55	
Twin	+0.12		41 19 56.23	
Spencer	+1.45	+1.25	109 21 42.34	4.83
Roman	−0.32		29 18 26.26	
Twin	+0.59		103 46 26.41	
Spencer	+1.36	+2.36	42 56 19.58	4.57
Mary	+0.41		33 17 18.58	
Twin	+0.33		176 44 23.40	
Spencer	+0.52	+0.55	1 08 19.90	0.11
Peterson	−0.30		2 07 16.81	
Twin	+0.48		62 26 30.19	
Roman	+1.48	+3.72	39 06 60.86	8.05
Mary	+1.76		78 26 37.00	

Table of triangles—Continued.

Station	Correction to angles from figure adjustment	Error of closure of triangle	Corrected spherical angles	Spherical excess
	″	″	° ′ ″	″
Twin	+0.22		135 24 27.18	
Roman	+0.27	+0.66	9 16 10.16	2.76
Peterson	+0.17		35 19 25.42	
Twin	−0.27		72 57 56.98	
Mary	−1.96	−2.94	25 20 43.55	2.42
Peterson	−0.71		81 41 21.89	
Ridge	−0.54		80 18 33.04	
Mary			57 24 47.22	3.14
Peterson	−0.26		42 16 42.88	
Ridge	+0.21		109 29 46.64	
Mary			32 04 03.68	2.04
Twin	+0.04		38 26 11.72	
Ridge	+0.75		29 11 13.60	
Peterson	−0.45	+0.08	39 24 39.01	1.32
Twin	−0.22		111 24 08.71	
Ridge	+1.14		101 57 42.40	
Peterson	−0.15	+0.48	37 17 22.20	3.62
Spencer	−0.51		40 44 59.02	
Ridge	+0.39		72 46 28.80	
Twin	+0.55	+0.95	65 20 14.69	2.41
Spencer	+0.01		41 53 18.92	
Ridge	−0.60		177 43 44.56	
Spencer	+1.35		1 02 60.66	0.12
Mary			1 13 14.90	
Rauch	+1.11		28 01 57.01	
Ridge	+0.64	+1.79	132 30 03.11	2.08
Peterson	+0.04		19 28 01.96	
Rauch	+0.42		37 27 23.69	
Ridge	−0.11	+0.14	103 18 49.51	1.88
Twin	−0.17		39 13 48.68	
Rauch	+0.21		100 50 07.24	
Ridge	−0.50	−0.47	30 32 20.71	1.33
Spencer	−0.18		48 37 33.38	
Rauch	−0.68		9 25 26.69	
Peterson	−0.49	−1.57	19 56 37.05	1.12
Twin	−0.40		150 37 57.38	
Rauch	−0.90		72 48 10.23	
Peterson	−0.19	−1.78	17 49 20.24	2.87
Spencer	−0.69		89 22 32.40	
Rauch	−0.21		63 22 43.55	
Twin	+0.73	+0.34	26 06 26.02	1.86
Spencer	−0.18		90 30 52.29	
Willamette south base	−2.54		3 16 28.28	
Mary			2 34 25.61	0.20
Ridge	−0.15		174 09 06.31	
Willamette south base	−2.27		50 21 55.35	
Mary			59 59 12.83	5.75
Peterson	−0.46		69 38 57.57	
Willamette south base	−2.47		58 06 43.97	
Mary			34 38 29.29	3.90
Twin	+0.40		87 14 50.64	

Table of triangles—Continued.

Station	Correction to angles from figure adjustment	Error of closure of triangle	Corrected spherical angles	Spherical excess
	"	"	° ′ ″	″
Willamette south base	−2.29		172 17 59.38	
Mary			1 21 10.71	0.23
Spencer	−1.13		6 20 50.14	
Willamette south base	+0.27		47 05 27.07	
Ridge	+0.69	+0.76	105 32 20.65	2.41
Peterson	−0.20		27 22 14.69	
Willamette south base	+0.07		54 50 15.69	
Ridge	−0.06	+0.37	76 21 07.05	1.66
Twin	+0.36		48 48 38.92	
Willamette south base	+0.25		169 01 31.10	
Ridge	−0.45	+0.02	3 34 38.25	0.15
Spencer	+0.22		7 23 50.80	
Willamette south base	−0.20		7 44 48.62	
Peterson	−0.25	−0.31	12 02 24.32	0.57
Twin	+0.14		160 12 47.63	
Willamette south base	−0.02		121 56 04.03	
Peterson	+0.06	−0.26	9 55 07.52	1.36
Spencer	−0.30		48 08 49.81	
Willamette south base	+0.19		114 11 15.42	
Twin	+0.19	+0.60	16 31 35.77	0.90
Spencer	+0.22		49 17 09.71	
Willamette south base	−0.15		100 11 57.65	
Spencer	−0.40	−0.62	41 13 42.58	0.38
Rauch	−0.07		38 34 20.15	
Willamette south base	−0.10		90 46 31.25	
Rauch	+0.28	+0.13	62 15 47.09	0.80
Ridge	−0.05		26 57 42.46	
Willamette south base	+0.17		137 51 58.32	
Rauch	−0.82	−0.90	34 13 50.09	1.13
Peterson	−0.25		7 54 12.72	
Willamette south base	−0.03		145 36 46.94	
Rauch	−0.14	+0.36	24 48 23.40	0.58
Twin	+0.53		9 34 50.24	
Willamette north base	−0.18		14 13 27.56	
Spencer	+0.11	−0.19	16 35 31.34	0.23
Willamette south base	−0.12		149 11 01.33	
Willamette north base	+0.56		47 02 18.55	
Spencer	−0.28	−0.59	57 49 13.93	1.03
Rauch	−0.87		75 08 28.55	
Willamette north base	+0.39		152 15 40.41	
Spencer	−0.10	+1.07	9 11 40.55	0.38
Ridge	+0.78		18 32 39.42	
Willamette north base	+0.75		32 48 51.00	
Willamette south base	+0.27	+0.22	110 37 01.02	0.42
Rauch	−0.80		36 34 08.40	
Willamette north base	+0.58		138 02 12.86	
Willamette south base	+0.37	+1.28	19 50 29.77	0.30
Ridge	+0.33		22 07 17.67	
Willamette north base	−0.17		105 13 21.86	
Rauch	+1.08	+1.19	25 41 38.69	0.68
Ridge	+0.28		49 04 60.13	

Table of triangles—Continued.

Station	Correction to angles from figure adjustment	Error of closure of triangle	Corrected spherical angles	Spherical excess
	″	″	° ′ ″	″
Willamette north base	−0.68		109 30 54.81	
Twin	−0.03	−0.60	37 47 28.15	1.33
Spencer	+0.11		32 41 38.37	
Willamette north base	+0.29		98 13 24.78	
Ridge	−0.39	+0.48	54 13 49.38	0.70
Twin	+0.58		27 32 46.54	
Willamette north base	−0.12		156 33 13.36	
Twin	−0.75	−1.53	11 41 02.14	0.50
Rauch	−0.66		11 45 45.00	
Willamette north base	−0.87		123 44 22.36	
Twin	−0.22	−1.39	21 15 52.38	0.66
Willamette south base	−0.30		34 59 45.92	
Yam	+0.01		40 28 18.33	
Peterson	+0.63	+1.70	77 57 10.58	7.24
Mary	+1.06		61 34 38.33	
Hult	+0.20		30 48 29.22	
Peterson	+0.89	+1.44	112 25 14.38	5.90
Mary	+0.35		36 46 22.30	
Hult	+0.38		86 08 19.71	
Peterson	+0.26	+0.44	34 28 03.80	4.89
Yam	−0.20		59 23 41.38	
Hult	+0.18		55 19 50.49	
Mary	+0.71	+0.70	24 48 16.03	6.23
Yam	−0.19		99 51 59.71	
Barnes	+0.58		33 40 50.52	
Hult	+0.19	+0.67	69 11 05.47	5.30
Yam	−0.10		77 08 09.31	
Larch	−0.31		20 04 36.88	
Hult	+0.79	+1.15	109 25 50.31	6.84
Yam	+0.67		50 29 39.65	
Larch	+0.02		51 25 37.01	
Hult	+0.60	−0.53	40 14 44.84	8.23
Barnes	−1.15		88 19 46.38	
Larch	+0.33		31 20 60.13	
Yam	−0.77	−1.01	26 38 29.66	6.69
Barnes	−0.57		122 00 36.90	
Star	+0.25		85 10 17.26	
Larch	+0.50	+1.51	64 13 06.92	3.13
Barnes	+0.76		30 36 38.95	
Davis	+1.14		58 32 10.74	
Star	+0.80	+2.00	76 04 01.99	4.50
Barnes	+0.06		45 23 51.77	
Red	−1.09		32 14 50.24	
Larch	−0.09	−2.27	51 09 49.05	2.58
Star	−1.09		96 35 23.29	
Red	+0.99		39 10 14.91	
Star	+0.04	+0.15	102 10 17.46	3.74
Davis	−0.88		38 39 31.37	
Lam	0.00		100 18 34.68	
Red	+0.46	−0.03	17 37 19.78	2.52
Davis	−0.49		62 04 08.06	

Table of triangles—Continued.

Station	Correction to angles from figure adjustment	Error of closure of triangle	Corrected spherical angles	Spherical excess
	″	″	° ′ ″	″
Len	+0.64		75 30 57.72	
Red	+0.24	+1.74	53 39 27.53	5.98
Davis	+0.86		50 49 40.73	
Len	+0.66		81 58 17.02	
Red	−0.22	+0.08	36 02 07.75	3.92
Lam	−0.36		61 59 39.15	
Len	+0.03		6 27 19.31	
Davis	−1.36	−1.69	11 14 27.32	0.46
Lam	−0.36		162 18 13.83	
Toutle	+0.35		73 22 12.76	
Len	−0.17	−0.08	33 06 33.71	1.44
Lam	−0.26		73 31 14.97	
Toutle	−0.22		101 27 32.92	
Len	−0.14	−1.47	39 33 53.02	2.62
Davis	−1.11		38 58 36.68	
Toutle	−0.57		28 05 20.16	
Lam	+0.62	+0.30	124 10 31.20	0.72
Davis	+0.25		27 44 09.36	
Huck	−0.96		38 16 40.54	
Len	+0.83	−1.70	67 41 32.41	3.79
Toutle	−1.57		74 01 50.84	
Bel	−0.62		24 34 28.86	
Len	−1.64	−3.20	110 47 19.98	4.17
Toutle	−0.94		44 38 15.33	
Bel	−1.36		62 19 13.29	
Len	−2.47	−5.26	43 05 47.57	4.73
Huck	−1.43		74 35 03.87	
Bel	−0.74		37 44 44.43	
Toutle	−0.63	−3.76	29 23 35.51	4.35
Huck	−2.39		112 51 44.41	
Hal	−0.73		65 45 23.14	
Bel	−0.49	−1.01	3 20 52.78	0.23
Huck	+0.21		110 53 44.31	
Rain	+0.75		27 30 38.90	
Bel	+1.25	+1.79	14 21 33.64	1.42
Hal	−0.21		138 07 48.88	
Rain	+0.67		29 57 02.52	
Bel	+0.76	+1.60	17 42 26.42	1.70
Huck	+0.17		132 20 32.76	
Rain	−0.08		2 26 23.62	
Hal	+0.94	+0.82	156 06 47.98	0.05
Huck	−0.04		21 26 48.45	
Hurst	−2.64		44 39 56.33	
Bel	−0.67	−2.32	49 20 41.62	4.08
Huck	+0.99		85 59 26.13	
Hurst	−1.59		46 10 43.42	
Bel	−0.18	−1.61	45 59 48.84	3.96
Hal	+0.16		87 49 31.70	
Hurst	−1.53		78 27 26.41	
Bel	−1.43	−5.62	31 38 15.20	4.18
Rain	−2.66		69 54 22.57	

Table of triangles—Continued.

Station	Correction to angles from figure adjustment	Error of closure of triangle	Corrected spherical angles	Spherical excess
	″	″	° ′ ″	″
Hurst	+1.05		1 30 47.09	
Huck	−0.78	−0.30	24 54 18.18	0.11
Hal	−0.57		153 34 54.84	
Hurst	+1.11		33 47 30.08	
Huck	−0.82	−1.70	46 21 06.63	1.80
Rain	−1.99		99 51 25.09	
Hurst	+0.06		32 16 42.99	
Hal	−0.37	−2.22	50 18 17.18	1.64
Rain	−1.91		97 25 01.47	
Pen	−0.62		33 28 16.06	
Hal	−0.41	−1.07	77 24 46.43	1.89
Rain	−0.04		69 06 59.40	
Pen	+0.01		87 12 49.13	
Hal	−0.04	−0.34	27 06 29.25	1.64
Hurst	−0.31		65 40 43.26	
Pen	+0.63		53 44 33.07	
Rain	−1.87	−1.49	28 18 02.07	1.39
Hurst	−0.25		97 57 26.25	
Tacoma south base	+0.91		69 10 39.96	
Pen	−0.86	−0.11	92 20 02.30	1.11
Hal	−0.16		18 29 18.85	
Tacoma south base	−0.90		102 39 44.25	
Pen	−0.24	−1.59	58 51 46.24	1.00
Rain	−0.45		18 28 30.51	
Tacoma south base	−0.31		164 18 03.76	
Pen	−0.88	−1.31	5 07 13.16	0.05
Hurst	−0.12		10 34 43.13	
Tacoma south base	−1.82		33 29 04.28	
Hal	−0.25	−2.55	58 55 27.58	1.78
Rain	−0.48		87 35 29.92	
Tacoma south base	−1.22		95 07 23.80	
Hal	+0.12	−1.54	8 37 10.40	0.58
Hurst	−0.44		76 15 26.38	
Tacoma south base	+0.59		61 38 19.51	
Rain	−1.42	−1.21	9 49 31.56	0.44
Hurst	−0.38		108 32 09.37	
Tacoma north base	+0.56		34 13 31.71	
Pen	+0.23	+0.94	33 41 27.66	0.35
Tacoma south base	+0.15		112 05 00.98	
Tacoma north base	−0.46		35 11 10.18	
Pen	−0.63	−1.28	126 01 29.96	1.49
Hal	−0.19		18 47 21.35	
Tacoma north base	−0.47		59 52 36.64	
Pen	−0.01	−0.76	92 33 13.90	1.93
Rain	−0.28		27 34 11.39	
Tacoma north base	−0.19		61 37 18.50	
Pen	−0.65	−1.10	38 48 40.82	0.58
Hurst	−0.26		79 34 01.26	
Tacoma north base	−1.02		0 57 38.47	
Tacoma south base	−1.06	−2.11	178 44 19.06	0.03
Hal	−0.03		0 18 02.50	

Table of triangles—Continued.

Station	Correction to angles from figure adjustment	Error of closure of triangle	Corrected spherical angles	Spherical excess
	″	″	° ′ ″	″
Tacoma north base	−1.03		25 39 04.93	
Tacoma south base	+0.75	−0.11	145 15 14.77	0.58
Rain	+0.17		9 05 40.88	
Tacoma north base	−0.75		27 23 46.79	
Tacoma south base	+0.16	−0.73	83 36 55.26	0.18
Hurst	−0.14		68 59 18.13	
Tacoma north base	−0.01		24 41 26.46	
Hal	−0.22	−0.55	58 37 25.08	2.33
Rain	−0.32		96 41 10.79	
Tacoma north base	+0.26		26 26 08.31	
Hal	+0.15	−0.16	8 19 07.90	0.73
Hurst	−0.57		145 14 44.52	
Tacoma north base	+0.27		1 44 41.85	
Rain	−1.59	−1.83	0 43 50.68	0.04
Hurst	−0.51		177 31 27.51	
Burn	+0.93		7 28 58.07	
Tacoma north base	+0.50		169 57 59.98	0.06
Pen			2 33 02.01	
Burn	+0.13		28 28 09.41	
Tacoma north base	−0.06	+0.37	135 44 28.27	0.14
Tacoma south base	+0.30		15 47 22.46	
Burn	+0.42		48 07 26.76	
Tacoma north base	+0.70	+1.29	108 20 41.49	0.21
Hurst	+0.17		23 31 51.96	
Burn	−0.80		20 59 11.34	
Pen			31 08 25.65	0.43
Tacoma south base	+0.45		127 52 23.44	
Burn	−0.51		40 38 28.69	
Pen			36 15 38.82	0.73
Hurst	−0.09		103 05 53.22	
Burn	+0.30		19 39 17.36	
Tacoma south base	−0.14	+0.19	67 49 32.80	0.25
Hurst	+0.03		92 31 10.09	
Kin	+0.80		73 06 26.93	
Tacoma north base	+0.19	+1.04	57 01 38.50	0.08
Burn	+0.05		49 51 54.65	
Wash	−0.29		29 18 58.42	
Kin	+0.62	+0.50	114 38 48.71	0.09
Tacoma north base	+0.17		36 02 12.96	
Wash	+0.20		62 24 49.45	
Kin	−0.18	−0.48	41 32 21.78	0.07
Burn	−0.50		76 02 48.84	
Wash	+0.49		33 05 51.03	
Tacoma north base	+0.02	+0.06	20 59 25.54	0.06
Burn	−0.45		125 54 43.49	
Bos	+0.15		59 34 55.77	
Kin	−0.19	−0.69	85 44 02.26	0.07
Wash	−0.65		34 41 02.04	
Gull	+0.23		36 32 14.15	
Bos	+0.05	−0.10	100 01 04.67	0.05
Kin	−0.38		43 26 41.23	

Table of triangles—Continued.

Station	Correction to angles from figure adjustment	Error of closure of triangle	Corrected spherical angles	Spherical excess
	″	″	° ′ ″	″
Gull	−0.29		98 56 22.48	
Bos	−0.11	−0.37	40 26 08.89	0.06
Wash	+0.03		40 37 28.69	
Gull	−0.53		62 24 08.32	
Kin	+0.19	−0.96	42 17 21.03	0.08
Wash	−0.62		75 18 30.73	
Dron	+0.26		34 39 30.32	
Bos	+0.13	+0.44	96 51 39.17	0.06
Kin	+0.05		48 28 50.57	
Dron	−0.08		94 11 34.11	
Bos	−0.02	+0.19	37 16 43.40	0.07
Wash	+0.29		48 31 42.56	
Dron	−0.34		59 32 03.79	
Kin	−0.24	−0.94	37 15 11.69	0.08
Wash	−0.36		83 12 44.60	
Smelt	−0.24		47 12 17.88	
Dron	−0.01	−0.01	41 02 20.60	0.05
Wash	+0.24		91 45 21.57	
Neill 2	+0.15		42 44 21.73	
Dron	+0.40	+0.26	88 02 19.21	0.06
Wash	−0.29		49 13 19.12	
Neill 2	+0.65		79 22 47.67	
Dron	+0.42	+1.80	46 59 58.62	0.06
Smelt	+0.73		53 37 13.77	
Neill 2	+0.50		36 38 25.94	
Wash	+0.53	+1.53	42 32 02.45	0.05
Smelt	+0.50		100 49 31.66	
Gull			77 09 57.49	
Wash	−0.03		57 07 32.99	0.07
Neill 2			45 42 29.59	
Tacoma astronomic station	+0.37		40 46 19.69	
Neill 2			26 35 08.08	0.05
Gull			112 38 32.28	

The maximum correction (−2″.73) to any angle is to the angle at Scott between the stations Fairview and Black. The mean error of an angle $a=\sqrt{\frac{\Sigma \Delta^2}{3n}}$, in which $\Sigma\Delta^2$ is the sum of the squares of the closing errors of the triangle and n is the number of triangles in the scheme, is for this arc +0″.97. The average closing error of a triangle for the 148 triangles is 1″.22. There are 11 triangles with closing errors greater than 3″.00 and the maximum is 6″.35.

ACCORD OF BASES.

There are three bases which serve to fix the length in the triangulation discussed in this report.

The Yolo base in the Thirty-ninth Parallel triangulation fixed the length of the line Snow Mountain West-Mount Helena and also the other two sides of the triangle Snow Mountain West-Marysville Butte-Mount Helena. The Willamette and Tacoma bases furnish two important tests of the accuracy of the triangulation.

In solving the normal equations in each section of the figure adjustment the length equation was, as usual, assigned to the last place, so that after all the conditions relating to triangle closures and ratios of length had been satisfied the discrepancy in length became known. In the following table the discrepancies developed between bases are given in terms of the seventh place of logarithms and are also expressed as ratios. A plus sign before the discrepancy expressed in terms of logarithms means that the first base mentioned is longer as measured than as computed through the intervening triangulation from the second base mentioned.

Bases	Discrepancy in seventh place of logarithms	Discrepancy expressed as a ratio
Mount Helena-Snow Mountain West to Willamette	+79	1/55000
Willamette to Tacoma	−19	1/229000

ACCORD OF AZIMUTHS.

Laplace azimuths were computed at three stations of this triangulation, viz, at Gazelle astronomic, Eugene astronomic, and Tacoma astronomic. It was so certain that the Laplace azimuth at each of these stations was more accurate than the geodetic azimuth computed through the triangulation that the existing discrepancy was distributed by means of three azimuth equations. These azimuth equations were assigned positions next preceding the length equations in the solution of the normal equations, so that after all the conditions relating to closures of triangles and ratios of sides had been satisfied, the discrepancy in azimuth became known. At Gazelle astronomic the discrepancy in azimuth amounted to 3″.14, the Laplace azimuth being larger than the United States standard azimuth by that amount. At Eugene astronomic the discrepancy in azimuth amounted to 2″.98, the Laplace azimuth being again greater than the geodetic azimuth computed through the triangulation.

Similarly, at Tacoma astronomic the discrepancy in azimuth ameunted to 3″.95 and again the Laplace azimuth was larger than the geodetic azimuth computed through the triangulation. It is evident therefore that if the United States standard azimuth at the Thirty-ninth Parallel is without twist, this entire arc has developed a twist amounting to the sum of these three discrepancies, a total of 10″.07.

The nearest Laplace stations in the Thirty-ninth Parallel triangulation are at Salt Lake City and at Ogden,[1] where the corrections to the United States standard value are −2″.85 and −2″.74, respectively. The nearest Laplace station in the California triangulation southward is at San Diego, where the correction to the United States standard value is −8″.77. From these corrections it might be inferred that the United States standard azimuth at Mount Helena requires also some correction of a minus sign, between 2″.8 and 8″.8, and the total twist of 10″.07 would then be increased. Additional Laplace stations nearer the junction at Mount Helena might add to our knowledge, but the azimuth observations made at Mount Tamalpais in 1859 and again in 1882 showed that a movement of the earth had taken place between those dates which was large enough to increase the azimuth nearly eight seconds,[2] and the line Mount Helena-Snow Mountain west is not too far from the disturbed area, to declare with certainty that its azimuth may not have been affected by the same cause.

TWIST IN TRIANGULATION.

The errors which are to be expected in computed geodetic azimuths are very much smaller than those which actually develop when tested by the Laplace azimuths. The expected error in this California-Washington arc is only 2″.3, as computed by a formula involving the minimum number of lines with which the azimuth may be carried (19 in this case), the probable error of

[1] See Supplementary Investigation in 1909 of the Figure of the Earth and Isostasy, p. 20.
[2] See p. 99 of Appendix 3, U. S. Coast and Geodetic Survey Report for 1907.

an observed direction and the number of conditions and directions.[1] The amount actually developed was 10″.1. In the California arc, of which the California-Washington arc is a continuation, the error in azimuth expected at its extremity, near San Diego, was ±2″.9, even though the azimuth was carried through 1,250 miles (2,000 kilometers) in the transcontinental triangulation and 500 miles (800 kilometers) through the California arc. The actual accumulated error in azimuth found at San Diego was 8″.8. At San Diego the correction to reduce to Laplace or true azimuth was minus, whereas at Tacoma the required correction was plus.

Confronted with these values for twist, the writer suggests that they may be caused by the unequal heating of the theodolite by the sun, even though the theodolite is protected from the direct rays. On triangulation extending in a north and south direction, as this arc does, where the observations were mainly made in the late afternoon, the west side of the instrument is undoubtedly warmer than the east side and the resulting angles opening to the west and to the east should be subject to systematic errors of opposite signs, and therefore twist would develop. If this theory is correct, an east and west arc should develop only a small amount of twist, well within the limits for the expected error. Arcs on which the observing was done at night should develop no twist exceeding that allowed by the probable error, for the temperature of the east and west sides of the instrument would be equal. It is expected that this theory will be tested in the near future on all of the arcs of primary triangulation now existing in the United States.

EXPLANATION OF POSITIONS, LENGTHS, AND AZIMUTHS, AND OF THE UNITED STATES STANDARD DATUM.

The lengths, as already fully explained in connection with the adjustments, all depend upon the Yolo, Willamette, and Tacoma bases. The lengths as given are all reduced to sea level. If the actual length of a line simply reduced to the horizontal is desired, it may be obtained with all the accuracy ordinarily needed by adding to the sea-level length as given a correction = (length of line as given) $\left[\frac{\text{mean elevation of the two ends of the line in meters}}{6370000}\right]$. The maximum value of this correction does not exceed $\frac{1}{2400}$ for the length of any portion of the triangulation here published. The maximum error made in the use of the above approximate formula for the correction does not exceed $\frac{1}{800000}$ for the length of any portion of this triangulation.

The positions—that is, the latitudes, longitudes, and azimuths—need special explanation.

All of the positions and azimuths have been computed upon the Clarke spheroid of 1866, as expressed in meters, which has been in use in the United States Coast and Geodetic Survey for many years.

After a spheroid has been adopted and all the angles and lengths in a triangulation have been fully fixed, it is still necessary, before the computation of latitudes, longitudes, and azimuths can be made, to adopt a standard latitude and longitude for a specified station and a standard azimuth of a line from that station. For convenience, the adopted standard position (latitude and longitude) of a given station, together with the adopted standard azimuth of a line from that station, is called the geodetic datum.

The primary triangulation in the United States was commenced at various points and existed at first as a number of detached portions, in each of which the geodetic datum was necessarily dependent only upon the astronomic stations connected with that particular portion. As examples of such detached portions of triangulation there may be mentioned the early triangulation in New England and along the Atlantic coast, a detached portion of the transcontinental triangulation centering on St. Louis and another portion of the same triangulation in the Rocky Mountain region, and three separate portions of triangulation in California in the latitude of San Francisco, in the vicinity of Santa Barbara Channel, and in the vicinity of San Diego. With the lapse of time these separate pieces have expanded until they have touched or overlapped.

[1] See Figure of the Earth and Isostasy from Measurements in the United States, p. 120.

The transcontinental triangulation, of which the office computation was completed in 1899, joins all of the detached portions mentioned and makes them one continuous triangulation. As soon as this took place the logical necessity existed of discarding the old geodetic data used in these various pieces and substituting one for the whole country, or at least for as much of the country as is covered by continuous triangulation. To do this is a very heavy piece of work and involved much preliminary study to determine the best datum to be adopted. On March 13, 1901, the superintendent adopted what is now known as the United States Standard Datum, and it was decided to reduce the positions to that datum as rapidly as possible. The datum adopted was that formerly in use in New England, and therefore its adoption did not affect the positions which had been used for geographic purposes in New England and along the Atlantic coast to North Carolina, nor those in the States of New York, Pennsylvania, New Jersey, and Delaware. The adopted datum does not agree, however, with that used in The Transcontinental Triangulation and in The Eastern Oblique Arc of the United States, publications which deal primarily with the purely scientific problem of the determination of the figure of the earth and which were prepared for publication before the adoption of the new datum.

As the adoption of such a standard datum is a matter of considerable importance, it is in order here to explain the desirability of this step more fully.

The main objects to be attained by the geodetic operations of the United States Coast and Geodetic Survey are, first, the control of the charts published by the Survey; second, the furnishing of geographic positions (latitudes and longitudes), of accurately determined elevations, and of distances and azimuths, to officers connected with the United States Coast and Geodetic Survey and to other organizations; third, the determination of the figure of the earth. For the first and second objects it is not necessary that the reference spheroid should be accurately that which most closely fits the geoid within the area covered, nor that the adopted geodetic datum should be absolutely the best that can be derived from the astronomic observations at hand. It is simply desirable that the reference spheroid and the geodetic datum adopted shall be, if possible, such a close approximation to the truth that any correction which may hereafter be derived from the observations which are now or may become available shall not greatly exceed the probable errors of such corrections. It is, however, very desirable that one spheroid and one geodetic datum be used for the whole country. In fact, this is absolutely necessary if a geodetic survey is to perform fully the function of accurately coordinating all surveys within the area which it covers. This is the most important function of a geodetic survey. To perform this function it is also highly desirable that when a certain spheroid and geodetic datum have been adopted for a country they be rigidly adhered to, without change, for all time, unless shown to be largely in error.

In striving to attain the third object, the determination of the figure of the earth, the conditions are decidedly different. This problem concerns itself primarily with astronomic observations of latitude, longitude, and azimuth, and with the geodetic positions of the points at which the astronomic observations were made, but is not concerned with the geodetic positions of other points fixed by the triangulations. The geodetic positions (latitudes and longitudes) of comparatively few points are therefore concerned in this problem. However, in marked contrast to the statements made in preceding paragraphs, it is desirable in dealing with this problem that, with each new important accession of data, a new spheroid fitting the geoid with the greatest possible accuracy, and new values of the geodetic latitudes, longitudes, and azimuths of the highest degree of accuracy, should be derived.

The United States Standard Datum was adopted with reference to positions furnished for geographic purposes, but has no reference to the problem of the determination of the figure of the earth. It is adopted with reference to the engineer's problem of furnishing standard positions and does not affect the scientist's problem of the determination of the figure of the earth.

The principles which guided in the selection of the datum to be adopted were: First, that the adopted datum should not differ widely from the ideal datum for which the sum of the station errors in latitude, longitude, and azimuth should each be zero; second, it was desirable that the adopted datum should produce minimum changes in the publications of the Survey,

including its charts; and, third, it was desirable, other things being equal, to adopt that datum which allowed the maximum number of positions already in the office registers to remain unchanged, and therefore necessitated a minimum amount of new computation. These considerations led to the adoption as the United States standard of the datum which had been in use for many years in the northeastern group of States and along the Atlantic coast as far as North Carolina.

An examination of the station errors available in 1903, on the United States Standard Datum, at 246 latitude stations, 76 longitude stations, and 152 azimuth stations, scattered widely over the United States from Maine to Louisiana and to California, indicated that this datum approaches closely the ideal with which the algebraic sum of the station errors of each class would be zero.[1]

The adopted United States Standard Datum, upon which the positions and azimuths given in this publication depend, may be defined in terms of the position of the station Meades Ranch as follows:

	°	′	″
ϕ =	39	13	26.686
λ =	98	32	30.506
α to Waldo =	75	28	14.52

Points are then said to be upon the United States Standard Datum when they are connected with the station Meades Ranch by a continuous triangulation, through which the corresponding latitudes, longitudes, and azimuths have been computed on the Clarke spheroid of 1866, as expressed in meters, starting from the above data.

The principal lists of geographic positions heretofore published on the United States Standard Datum throughout the whole United States are contained in the following publications of the United States Coast and Geodetic Survey and of other organizations:

Appendix 8 of the Report for 1885, positions in Massachusetts and Rhode Island; Appendix 8 of the Report for 1888, positions in Connecticut; Appendix 8 of the Report for 1893, positions in Pennsylvania, Delaware, and Maryland; Appendix 10 of the Report for 1894, positions in Massachusetts; Appendix 6 of the Report for 1901, positions in Kansas and Nebraska; Appendix 3 of the Report for 1902, positions in Kansas, Missouri, Nebraska, and Colorado; Appendix 4 of the Report for 1903, positions in Kansas, Oklahoma, and Texas; Appendix 9 of the Report for 1904, positions in California; Appendix 5 of the Report for 1905, positions in Texas; Appendix 3 of the Report for 1907, positions in California; Appendix 5 of the Report for 1910, positions in California; Appendix 4 of the Report for 1911, positions in Nebraska, Minnesota, North Dakota, and South Dakota; Appendix 5 of the Report for 1911, positions in Texas; Appendix 6 of the Report for 1911, positions in Florida; Special Publication No. 11, positions in Texas, New Mexico, Arizona, and California; in Appendix EEE, pages 2905–3031, Annual Report of the Chief of Engineers, 1902, positions of points on or near the Great Lakes; in the publications of the Massachusetts Harbor and Land Commission; and in various bulletins of the United States Geological Survey.

TABLE OF POSITIONS.

In the tables of positions the latitude and longitude of each point are given on the United States Standard Datum (see p. 31), also the length and azimuth of each line observed over, whether in one or both ways. Along with the latitude and longitude of each point the lengths and azimuths are given of lines from that point to other points of the triangulation. No lengths or azimuths are repeated, and for a given line the length and azimuth will generally be found opposite the position of the last mentioned of the two stations involved.

For the convenience of the draftsman a column of "seconds in meters" is given, in which is placed the length (in meters) of each small arc of a meridian or parallel corresponding to the

[1] This is further borne out in the reduction of 765 astronomic stations in connection with the "Supplementary investigation in 1909 of the figure of the earth and isostasy," by J. F. Hayford, published by the U. S. Coast and Geodetic Survey.

seconds of the given latitude or longitude. To facilitate further the use of the tables, a column is given of the logarithms of the lengths. It must be remembered that it is the logarithm which is derived first from the computation, the lengths given in this table being then derived from the corresponding logarithms.

The rule followed in recent publications of this Office has been to give latitudes and longitudes to thousandths of seconds for all points the positions of which are fixed by fully adjusted triangulation. Points, the positions of which are given to hundredths of seconds only, are marked by footnotes as being without check (observed from only two stations) or checked by verticals only.

In the columns giving azimuths, distances, and logarithms of distances, the accuracy is indicated to a certain extent by the number of decimal places given, it being understood that in each case two doubtful figures are given. In some cases there is very little doubt of the correctness of the second figure from the right, while in a few cases some doubt may be cast on the third figure from the right.

These tables may be conveniently consulted by using as finders the seven sketches at the end of this appendix, and the index on pages 75 to 78. In the third column of the index will be found for each point a reference to the page on which its description is given, in the fourth column the number of the sketch on which it appears, and in the fifth column the page on which its elevation above sea level will be found.

For the convenience of those who wish to convert the distances given in this table or the elevations given later on from meters into feet the following conversion table is here inserted:

Meters	Feet	Feet	Meters
1	3.280833	1	0.3048006
2	6.561667	2	0.6096012
3	9.842500	3	0.9144018
4	13.123333	4	1.2192024
5	16.404167	5	1.5240030
6	19.685000	6	1.8288037
7	22.965833	7	2.1336043
8	26.246667	8	2.4384049
9	29.527500	9	2.7432055
10	32.808333	10	3.0480061

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithm
Principal points	° ′ ″		° ′ ″	° ′ ″		*Meters*	
Mount Helena	38 40 11.080	341.6	245 56 18.019	67 22 03.416	Mount Lola	213873.23	5.33015644
1876	122 37 57.817	1397.7	324 01 34.822	144 28 18.913	Mount Diablo	107728.96	5.03233246
			269 20 15.615	90 58 57.203	Round Top	229100.84	5.3600267
Marysville Butte	39 12 22.361	689.6	50 03 28.78	229 32 49.63	Mount Helena	92269.81	4.9650596
1876	121 49 11.540	276.9	103 30 30.51	282 54 51.87	Snow Mountain west	83129.44	4.9197549
Snow Mountain west	39 22 38.452	1185.8	352 06 02.01	172 10 45.86	Mount Helena	79298.64	4.8992657
1892	122 45 28.619	685.0	18 03 03.98	197 49 26.49	Ross Mountain	101704.73	5.0073412
Snow Mountain east	39 23 02.008	61.9	283 29 49.08	104 05 12.82	Marysville Butte	82741.44	4.9177231
1876	122 45 04.847	116.0	352 34 48.70	172 39 17.60	Mount Helena	79942.78	4.9027792
			38 04 15.69	218 04 00.61	Snow Mountain west	922.76	2.9650893
Kent	39 58 01.752	54.0	316 41 36.16	137 16 41.00	Marysville Butte	115540.16	5.0627330
1904	122 44 14.449	342.8	1 04 01.62	181 03 29.44	Snow Mountain east	64768.60	4.8113645
Lyons	40 18 06.101	188.2	7 18 50.85	187 11 54.82	Marysville Butte	122611.05	5.0885296
1904	121 38 21.007	496.1	43 24 27.26	222 41 41.92	Snow Mountain east	139446.43	5.1444074
			68 42 27.63	247 59 59.25	Kent	100696.76	5.0030155
Bally	40 36 11.939	368.3	291 00 16.70	111 39 38.03	Lyons	92064.79	4.9640936
1904	122 39 00.370	8.7	6 01 26.68	185 58 03.60	Kent	71026.97	4.8514233
Round	40 48 19.882	613.3	334 10 02.02	154 22 27.03	Lyons	62103.91	4.7931190
1904	121 57 26.873	629.8	35 40 46.89	215 10 27.70	Kent	114242.48	5.0578276
			69 14 22.18	248 47 16.01	Bally	62695.07	4.7972334
Spur	41 24 14.648	451.9	339 42 45.15	159 54 13.91	Roun	70823.50	4.8501774
1904	122 14 54.491	1265.7	20 56 17.28	200 40 28.60	Bally	95128.60	4.9783111

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithm
Principal points—Contd.	° ′ ″		° ′ ″	° ′ ″		*Meters*	
Mears	41 07 29.538	911.3	208 15 08.51	28 23 01.90	Spur	35221.98	4.5468137
1904	122 26 52.260	1219.1	310 30 15.44	130 49 32.84	Round	54422.85	4.7357813
			16 28 16.81	196 20 20.42	Bally	60376.39	4.7808671
Boliver (Cal.)	41 15 35.575	1097.5	250 01 14.88	70 22 17.82	Spur	47264.02	4.6745307
1904	122 46 46.811	1089.8	298 11 54.84	118 25 01.56	Mears	31618.27	4.4999381
			351 26 43.00	171 31 48.60	Bally	73724.24	4.8676103
Soda (Oreg.)	42 03 54.670	1686.8	345 19 52.95	165 29 03.58	Spur	75875.33	4.8801006
1904	122 28 41.648	957.5	15 46 47.39	195 34 46.02	Boliver	92897.87	4.9680058
Gazelle astronomic station	41 31 36.248	1118.3	183 13 35.19	3 15 12.92	Soda	59900.25	4.7774286
1904	122 31 08.281	192.0	300 59 40.18	121 10 24.99	Spur	26386.99	4.4213899
Sterling (Oreg.)	42 01 03.864	119.2	261 00 09.26	81 16 33.53	Soda	34213.03	4.5341916
1904	122 53 11.434	263.1	321 51 54.19	142 17 22.56	Spur	86401.66	4.9365221
			353 55 38.45	173 59 54.01	Boliver	84640.63	4.9275789
Rust	42 37 10.930	337.3	9 58 58.92	189 53 41.33	Soda	62533.30	4.7961114
1904	122 20 50.147	1142.9	33 47 58.14	213 26 11.14	Sterling	80293.46	4.9046802
Onion	42 41 31.762	980.1	276 02 52.70	96 38 45.29	Rust	72802.92	4.8621488
1904	123 13 46.921	1068.1	318 07 09.53	138 37 33.00	Soda	93169.15	4.9692721
			339 12 19.09	159 26 11.48	Sterling	80071.78	4.9034795
Black	43 09 37.503	1157.3	350 59 07.43	171 03 51.98	Rust	60812.13	4.7839902
1904	122 27 48.236	1089.8	50 31 05.83	229 59 46.98	Onion	81362.20	4.9104227
White	43 07 14.428	445.3	264 24 10.96	84 47 44.04	Black	46910.01	4.6712655
1904	123 02 14.761	333.7	314 23 02.31	134 51 12.74	Rust	79232.11	4.8989012
			18 19 13.10	198 11 21.87	Onion	50126.59	4.7000681
Scott	43 22 21.758	671.5	295 36 15.65	116 00 57.67	Black	54169.15	4.7337520
1904	123 03 50.517	1137.3	355 34 45.07	175 35 50.67	White	28083.48	4.4484509
Fairview	43 35 10.459	322.8	341 59 37.72	162 07 24.98	Black	49726.19	4.6965851
1904	122 39 08.622	193.4	31 14 40.80	210 58 49.21	White	60413.38	4.7811331
			54 40 43.54	234 23 43.86	Scott	40889.41	4.6116108
Yellow	43 32 48.849	1507.5	265 37 03.17	86 08 04.66	Fairview	60770.94	4.7836960
1904	123 24 09.568	214.9	305 06 41.39	125 20 39.92	Scott	33550.08	4.5256936
			327 50 53.15	148 05 55.44	White	55853.69	4.7470519
Spencer	43 59 00.715	22.1	320 57 05.87	141 15 27.90	Fairview	56716.00	4.7537056
1903	123 05 41.248	919.3	27 10 28.02	206 57 41.38	Yellow	54479.49	4.7362330
Roman	43 54 45.041	1390.1	261 04 53.49	81 31 39.25	Spencer	52195.22	4.7176307
1903	123 44 14.987	334.5	292 09 05.10	112 54 06.43	Fairview	94618.63	4.9759767
			326 17 38.82	146 31 32.08	Yellow	48763.89	4.6880983
Mary	44 30 17.369	536.1	327 37 54.62	147 57 02.02	Spencer	68458.53	4.8354276
1903	123 33 05.732	126.6	12 47 13.03	192 39 26.37	Roman	67471.43	4.8291199
Peterson	44 30 38.293	1182.0	9 50 19.67	189 45 01.69	Spencer	59436.11	4.7740504
1903	122 58 05.537	122.3	43 02 28.28	222 30 17.06	Roman	90538.25	4.9568321
			89 24 24.75	268 59 52.49	Mary	46396.18	4.6664822
Twin	44 19 31.401	969.3	10 57 11.34	190 53 21.59	Spencer	38685.83	4.5875519
1905	123 00 11.426	253.2	52 17 07.57	231 46 27.22	Roman	74563.88	4.8725285
			114 43 37.75	294 20 36.03	Mary	48015.44	4.6813809
			187 41 34.73	7 43 02.86	Peterson	20772.15	4.3174815
Ridge	44 16 02.051	63.3	146 33 52.16	326 24 39.71	Mary	31664.07	4.5005667
1905	123 19 55.940	1240.7	226 52 25.20	47 07 41.87	Peterson	39658.11	4.5983320
			256 03 38.80	76 17 26.03	Twin	27042.78	4.4320513
			328 50 07.61	149 00 02.67	Spencer	36807.85	4.5659404
Rauch	44 00 50.965	1573.0	179 22 37.92	359 22 28.32	Ridge	28122.31	4.4490510
1903	123 19 42.158	939.1	207 24 34.93	27 39 39.91	Peterson	62214.07	4.7938886
			216 50 01.62	37 03 37.36	Twin	43271.64	4.6362034
			280 12 45.16	100 22 29.29	Spencer	19042.44	4.2797227
Willamette south base	44 04 06.905	213.1	61 44 15.53	241 38 25.01	Rauch	12751.68	4.1055673
1903	123 11 17.933	399.1	149 14 18.50	328 59 05.33	Mary	56484.64	4.7519303
			152 30 46.78	332 24 45.86	Ridge	24893.17	4.3960802
			199 36 13.85	19 45 27.19	Peterson	52166.74	4.7173937
			207 21 02.47	27 28 47.11	Twin	32144.90	4.5071120
			321 32 17.88	141 36 11.87	Speucer	12063.61	4.0814772
Willamette north base	44 11 37.076	1144.4	25 09 09.08	205 04 16.61	Rauch	22023.74	4.3428910
1905	123 12 41.921	931.0	130 22 30.94	310 17 28.19	Ridge	12636.24	4.1016178
			228 35 55.72	48 44 39.50	Twin	22169.74	4.3457607
			338 06 50.53	158 11 43.21	Spencer	25150.86	4.4005529
			352 20 18.07	172 21 16.55	Willamette south base	14019.38	4.1467287
Seavies 2	44 06 24.663	761.2	28 21 03.50	208 17 12.93	Spencer	15565.01	4.1921494
1908	123 00 09.593	213.3	74 06 22.54	253 58 37.54	Willamette south base	15464.74	4.1893425
Pisgah	44 00 19.836	612.2	76 54 39.61	256 49 13.38	Spencer	10746.63	4.0312723
1908	122 57 51.568	1148.8	111 24 00.79	291 14 40.27	Willamette south base	19274.05	4.2849731
			164 45 06.65	344 43 30.67	Seavies 2	11671.80	4.0671380
Eugene astronomic station	44 03 30.319	935.8	232 47 15.95	52 50 57.77	Seavies 2	8904.00	3.9495852
1894	123 05 28.438	633.0	299 58 42.95	120 04 00.50	Pisgah	11750.21	4.0700458
			1 57 54.04	181 57 45.14	Spencer	8326.04	3.9204384

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithm
Principal points—Contd.	° ′ ″		° ′ ″	° ′ ″		*Meters*	
Yam	45 03 44.993	1388.9	347 14 12.38	167 21 35.33	Peterson	62864.86	4.7984079
1903	123 08 34.292	750.3	27 42 30.71	207 25 14.16	Mary	69907.19	4.8445219
Hult	44 57 48.151	1486.2	22 00 26.69	201 49 39.13	Peterson	54230.41	4.7342429
1903	122 42 45.524	997.8	52 48 55.91	232 13 30.19	Mary	83742.39	4.9229453
			108 08 46.40	287 50 31.00	Yam	35658.40	4.5521619
Barnes (Oreg.)	45 31 36.526	1127.6	357 18 16.35	177 19 51.87	Hult	62686.70	4.7971754
1903	122 45 00.031	0.7	30 59 06.87	210 42 21.09	Yam	60103.71	4.7789013
Larch (Oreg.)	45 31 59.615	1840.4	38 01 16.39	217 34 36.71	Hult	80147.83	4.9038918
1903	122 05 13.018	282.5	58 05 53.27	237 20 51.35	Yam	97962.33	4.9910591
			89 26 53.40	268 58 29.97	Barnes	51802.18	4.7143480
Star (Wash.)	45 44 47.711	1473.0	333 33 31.93	153 40 00.32	Larch	26471.61	4.4227804
1906	122 14 16.246	351.1	58 43 49.19	238 21 51.02	Barnes	46811.84	4.6703557
Davis (Wash.)	45 59 37.452	1156.3	314 32 26.39	134 47 51.18	Star	39075.00	4.5918990
1906	122 35 44.667	961.1	13 04 37.13	192 57 59.25	Barnes	53266.40	4.7264533
Red (Wash.)	45 56 07.249	223.8	25 01 17.31	204 49 49.37	Larch	49284.42	4.6927096
1906	121 49 12.344	265.9	57 16 07.55	236 58 08.64	Star	38644.78	4.5870908
			96 26 22.46	275 52 55.02	Davis	60473.22	4.7815631
Warren (Oreg.)	45 48 33.229	1025.9	225 52 07.84	46 03 54.50	Davis	29504.23	4.4698843
1903	122 52 08.679	187.4	296 26 15.40	116 59 49.58	Larch	68230.27	4.8339771
			343 29 22.08	163 34 28.69	Barnes	32731.73	4.5149689
Lam	46 07 57.903	1787.8	293 35 59.64	114 03 42.24	Red	54305.40	4.7348430
1906	122 27 42.295	908.0	33 54 34.32	213 48 46.96	Davis	18607.75	4.2696939
Len	46 18 45.173	1394.8	329 52 16.76	150 05 49.99	Red	48420.72	4.6850313
1906	122 08 00.508	10.9	45 23 14.48	225 03 14.29	Davis	50309.34	4.7016486
			51 50 33.78	231 36 20.49	Lam	32263.10	4.5087061
Toutle	46 17 10.419	321.7	264 39 01.27	84 57 07.49	Len	32288.32	4.5090454
1905	122 33 02.971	63.6	338 01 14.03	158 05 05.52	Lam	18392.59	4.2646430
			6 06 34.19	186 04 37.60	Davis	32696.06	4.5144954
Huck	46 42 45.136	1393.8	332 25 33.37	152 38 39.90	Len	50110.83	4.6999316
1905	122 26 04.593	97.6	10 42 13.91	190 37 10.43	Toutle	48221.32	4.6832391
Bel	46 47 04.983	153.9	15 52 53.95	195 44 27.47	Len	54550.97	4.7368025
1905	121 56 22.841	484.6	40 27 22.81	220 00 45.94	Toutle	72585.28	4.8608486
			78 12 07.24	257 50 29.50	Huck	38661.55	4.5872792
Hal	46 43 52.344	1616.3	261 10 35.73	81 33 00.02	Bel	39612.33	4.5978304
1905	122 27 08.201	174.1	326 55 58.87	146 56 45.18	Huck	2476.21	3.3937882
Rain	46 50 07.065	218.1	275 21 54.89	95 54 33.66	Bel	57237.74	4.7576825
1905	122 41 09.422	199.7	302 52 33.79	123 02 46.85	Hal	21267.75	4.3277217
			305 18 57.41	125 29 56.74	Huck	23553.23	4.3720505
Ilurst	47 05 02.549	78.7	307 07 42.31	127 32 48.86	Bel	54863.28	4.7392818
1905	122 30 44.966	948.5	351 47 38.64	171 51 03.36	Huck	41723.67	4.6203825
			353 18 25.73	173 21 04.03	Hal	39491.49	4.5965035
			25 35 08.72	205 27 32.32	Rain	30643.15	4.4863335
Pen	47 02 05.064	156.4	20 34 48.68	200 27 33.28	Hal	36029.17	4.5566543
1905	122 17 11.732	247.7	54 03 04.74	233 45 34.39	Rain	37635.66	4.5755995
			107 47 37.81	287 37 42.47	Hurst	18016.34	4.2556667
Tacoma south base	47 04 38.837	1199.3	292 48 20.30	112 54 50.97	Pen	12223.72	4.0872032
1905	122 26 05.422	114.4	1 59 00.26	181 58 14.43	Hal	38514.80	4.5856276
			35 28 04.55	215 17 03.88	Rain	33016.51	4.5187312
			97 06 24.06	277 02 59.34	Hurst	5942.41	3.7739623
Tacoma north base	47 11 09.189	283.8	326 29 52.90	146 36 18.63	Pen	20138.56	4.3040283
1905	122 25 58.206	1225.5	0 43 24.61	180 43 19.32	Tacoma south base	12055.570	4.0811877
			1 41 03.08	181 40 11.93	Hal	50568.14	4.7038770
			26 22 29.54	206 11 23.00	Rain	43468.90	4.6381786
			28 07 11.39	208 03 41.21	Hurst	12834.17	4.1083677
Burn	47 13 50.673	1564.9	316 25 07.53	136 27 52.88	Tacoma north base	6881.62	3.8376905
1905	122 29 43.535	915.7	323 54 05.60	144 03 16.62	Pen	26941.63	4.4304238
			344 53 16.94	164 55 56.86	Tacoma south base	17650.12	4.2467477
			4 32 34.29	184 31 49.25	Hurst	16360.54	4.2137976
Kin	47 14 02.319	71.6	13 30 16.14	193 29 31.38	Tacoma north base	5498.45	3.7402404
1905	122 24 57.219	1203.6	86 36 43.07	266 33 12.88	Burn	6033.54	3.7805720
Wash	47 16 14.398	444.6	308 06 03.35	128 09 04.85	Kin	6606.58	3.8199767
1905	122 29 04.374	91.9	337 25 01.77	157 27 18.42	Tacoma north base	10206.74	4.0088869
			10 30 52.80	190 30 24.04	Burn	4514.25	3.6545858
Bos	47 15 59.493	1837.2	33 54 32.01	213 53 07.11	Kin	4359.53	3.6394393
1905	122 23 01.599	33.6	93 29 27.78	273 25 01.31	Wash	7639.85	3.8830851
Gull	47 17 52.574	1623.6	313 53 29.85	133 55 36.67	Bos	5035.48	3.7020410
1891	122 25 54.219	1139.2	350 25 44.00	170 26 25.88	Kin	7211.04	3.8579978
			52 49 52.33	232 47 32.62	Wash	5016.11	3.7003670
Dron	47 18 00.812	25.1	310 43 39.16	130 46 11.18	Bos	5739.79	3.7588960
1905	122 26 28.511	599.0	345 23 09.48	165 24 16.54	Kin	7611.11	3.8814482
			44 55 13.27	224 53 18.75	Wash	4639.82	3.6665016

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithm
Principal points—Contd.	° ′ ″		° ′ ″	° ′ ″		*Meters*	
Smelt	47 17 46.283	1429.3	265 53 53.35	85 57 33.87	Dron	6320.14	3.8007266
	122 31 28.575	600.4	313 06 11.23	133 07 57.18	Wash	4151.58	3.6182138
Neill 2	47 19 55.014	1699.0	312 55 19.83	132 57 32.48	Dron	5177.06	3.7140833
1905	122 29 28.963	608.1	355 39 41.56	175 39 59.63	Wash	6832.69	3.8345920
			32 18 07.50	212 16 39.57	Smelt	4702.78	3.6723549
Tacoma astronomic station	47 15 47.911	1479.6	156 34 15.80	336 32 20.05	Neill 2	8317.79	3.9200079
1892	122 26 51.446	1081.6	197 20 35.49	17 21 17.53	Gull	4033.36	3.6056668
Supplementary points.							
Mount St. John [1]	39 26 03.17	97.8	176 16 31	356 14 48	Kent	59296.6	4.773030
1904	122 41 32.14	768.7	288 19 10	108 52 20	Marysville Butte	79376.0	4.899689
Corning tower	39 55 40.774	1257.6	95 23 05.04	275 01 34.16	Kent	47923.97	4.6805528
1904	122 10 44.008	1044.9	227 46 57.18	48 07 49.11	Lyons	61958.90	4.7921037
			338 49 44.76	159 03 28.06	Marysville Butte	85868.67	4.9338347
Corning astronomic station	39 55 40.48	1248.5	247 24 10	67 24 11	Corning tower	23.41	1.36933
1908	122 10 44.92	1066.6					
Mount Linn, top of peak	40 02 12.617	389.1	195 17 14.5	15 25 07.8	Bally	65228.9	4.814440
1904	122 51 11.855	281.0	253 44 09.8	74 31 09.3	Lyons	107523.9	5.031505
			315 46 22.4	136 25 54.9	Marysville Butte	127977.0	5.107132
Lassen Peak	40 29 18.614	574.1	10 50 33.3	190 38 25.4	Marysville Butte	144911.5	5.161103
1904	121 30 15.513	365.4	28 56 28.7	208 51 14.1	Lyons	23693.5	4.374630
			61 31 03.3	240 43 16.5	Kent	119851.7	5.078644
Bully Choop	40 33 20.346	627.6	241 41 39.9	61 46 12.1	Bally	11176.0	4.048286
1904	122 45 58.884	1385.4	286 03 36.6	106 47 28.1	Lyons	99722.2	4.998792
			357 49 40.2	177 50 47.7	Kent	65392.2	4.815526
Redding courthouse	40 34 58.278	1797.6	96 06 13.3	275 56 17.2	Bally	21661.1	4.335680
1908	122 23 44.281	1041.5	236 07 45.1	56 24 53.6	Round	44531.8	4.648670
Redding astronomic station	40 34 19.354	597.0	99 11 08.7	279 01 09.1	Bally	21951.3	4.341461
1904	122 23 38.684	909.8	173 44 41.4	353 44 37.8	Redding courthouse	1207.8	3.082013
			234 46 13.9	55 03 18.7	Round	45104.3	4.654218
Redding south base	40 34 28.152	868.3	50 02 58.9	230 02 49.9	Redding astronomic station	422.6	2.625930
1908	122 23 24.911	585.9					
			91 29 00.2	271 28 50.5	Hill	351.4	2.545762
			153 53 14.2	333 53 01.6	Redding courthouse	1034.9	3.014915
Redding north base	40 34 42.167	1300.7	352 28 22.7	172 28 24.2	Redding south base	436.1	2.639542
1908	122 23 27.340	643.0	20 46 04.0	200 45 56.6	Redding astronomic station	752.6	2.876541
			34 47 58.0	214 47 49.9	Hill	515.4	2.712126
			141 17 01.8	321 16 50.8	Redding courthouse	637.0	2.804122
Hill	40 34 28.446	877.4	354 26 27.4	174 26 28.2	Redding astronomic station	281.8	2.449913
1908	122 23 39.845	937.2					
			173 31 58.0	353 31 55.1	Redding courthouse	926.1	2.966656
Crater Peak	40 41 54.374	1677.2	2 19 29.9	182 18 40.7	Lyons	44091.3	4.644353
1904	121 37 05.274	123.8	83 26 10.3	262 45 50.1	Bally	87920.3	4.944089
			124 23 11.6	303 50 35.4	Mears	84433.2	4.926513
Thompson Peak [1]	40 56 37.67	1162.0	225 27 58	45 52 36	Spur	73149.8	4.864213
1904	122 52 19.33	452.1	240 26 59	60 43 42	Mears	40949.0	4.612243
Saw Tooth	40 58 21.995	678.4	232 35 06.1	53 04 51.4	Spur	79280.8	4.899168
1904	123 00 05.396	126.2	249 52 27.8	70 14 16.7	Mears	49517.9	4.694762
			324 01 15.2	144 15 01.6	Bally	50626.0	4.704374
Mount Eddy, cairn	41 19 12.449	384.0	75 14 54.3	255 02 58.9	Boliver	26103.3	4.416695
1904	122 28 42.470	987.8	180 00 47.0	0 00 47.6	Soda	82750.8	4.917772
			244 04 37.5	64 13 44.6	Spur	21384.1	4.330090
Black Butte, cairn	41 22 00.307	9.5	148 20 23.9	327 58 52.5	Sterling	85107.9	4.929970
1904	122 20 49.936	1160.6	141 07 26.9	321 00 37.6	Gazelle astronomic station	22841.3	4.358721
			243 19 08.0	63 23 03.0	Spur	9240.3	3.965684
			172 02 30.6	351 57 16.6	Soda	78335.2	4.893957
Mount Shasta, top of	41 24 33.797	1042.7	343 25 01.5	163 34 21.4	Round	69943.8	4.844749
1904	122 11 38.482	893.8	23 21 05.6	203 03 08.3	Bally	97392.4	4.988525
			34 01 48.5	213 51 45.8	Mears	38089.6	4.580807
			71 28 59.0	251 05 46.5	Bollver	51760.1	4.713995
			139 46 03.1	319 18 24.3	Sterling	88806.4	4.948444
			162 06 35.9	341 55 14.8	Soda	76578.7	4.884108
China Mountain, not the cairn	41 22 41.420	1277.8	4 12 29.0	184 09 32.3	Bally	86279.2	4.935906
	122 34 31.102	722.7	52 33 09.7	232 25 03.9	Boliver	21572.8	4.333907
1904			186 00 38.1	6 04 30.6	Soda	76730.5	4.884968
			263 53 09.2	84 06 07.2	Spur	27486.9	4.439125
Russian Peak, north point	41 16 59.106	1823.4	183 44 19.2	3 46 53.2	Sterling	81770.4	4.912596
1904	122 57 03.164	73.6	256 53 40.8	77 21 31.2	Spur	60306.8	4.780366
			280 07 36.0	100 14 22.5	Bollver	14575.5	4.163622

[1] Checked by vertical angles only.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithm
Supplementary points—Continued.	° ′ ″		° ′ ″	° ′ ″		*Meters*	
Russian Peak, south point[1]	41 16 58.70	1810.8	256 53 00	77 20 51	Spur	60311.2	4.780398
1904	122 57 03.24	75.4	292 25 38	112 45 31	Mears	45701.9	4.659934
Marble Mountain	41 34 46.625	1438.4	199 11 35.3	19 19 46.2	Sterling	51540.5	4.712199
1904	123 05 27.947	647.4	223 09 00.2	43 33 31.4	Soda	74170.1	4.870229
			285 12 26.0	105 45 55.8	Spur	73017.5	4.863427
Little Shasta	41 43 14.240	439.4	42 30 04.4	222 07 53.9	Bolliver	69201.4	4.840115
1904	122 13 18.490	427.4	121 06 02.3	300 39 25.2	Sterling	64299.7	4.808209
			151 00 27.3	330 50 10.8	Soda	43789.9	4 641374
Goose Nest, tall tree (Cal.)	41 48 58.928	1818.0	36 03 53.7	215 52 42.6	Gazelle astronomic station	39747.9	4.599314
1904	122 14 19.005	438.8	36 19 45.5	215 58 13.8	Bolliver	76540.3	4.883890
			144 21 42.8	324 12 06.2	Soda	34039.0	4.531977
			112 48 33.3	292 22 35.1	Sterling	58217.6	4.765054
Preston Peak (Cal.)	41 50 07.93	244.7	198 10 15	18 25 38	Onion	100218.3	5.000947
	123 36 39.82	918.8	251 08 55	71 37 58	Sterling	63415.7	4.802197
Greyback (Oreg.)	42 06 37.101	1144.7	185 55 39.3	5 58 58.1	Onion	64982.4	4.812796
1904	123 18 41.721	958.5	210 31 32.8	31 06 01.1	Black	135820.7	5.132966
			286 08 49.7	106 25 54.9	Sterling	36655.3	4.564137
Pilot Rock	42 01 51.653	1593.7	12 08 01.3	191 59 15.8	Bolliver	87578.8	4.942399
1904	122 33 36.073	829.8	86 59 17.2	266 46 10.4	Sterling	27080.5	4.432656
			240 41 59.1	60 45 16.4	Soda	7762.2	3.889986
			339 28 26.6	159 40 53.0	Spur	74302.4	4.871003
Siskiyou[1]	42 03 44.11	1361.0	151 24 26	331 05 35	Onion	79806.8	4.902040
1904	122 45 49.09	1128.7	269 06 50	89 18 18	Soda	23625.0	4.373372
Kerby[1]	42 13 14.81	456.9	199 49 51	19 59 12	Onion	55688.7	4.745767
1904	123 27 36.84	844.9	243 48 38	64 33 41	Rust	101757.6	5.007567
Ashland Peak, cairn	42 04 52.547	1621.3	148 14 12.4	327 53 25.9	Onion	79960.0	4.902873
1904	122 42 57.867	1330.0	206 48 39.6	27 03 34.1	Rust	67086.5	4.826635
			275 06 14.9	95 15 48.7	Soda	19763.9	4.295873
			332 29 50.9	152 48 31.8	Spur	84676.5	4.927763
			3 20 37.4	183 18 05.3	Bolliver	91380.6	4.960854
Wagner	42 07 05.737	177.0	149 38 40.8	329 20 13.1	Onion	73992.2	4.869186
1904	122 46 24.287	558.0	192 10 58.1	12 29 34.1	Black	118526.6	5.073816
			212 04 35.7	32 21 49.6	Rust	65838.1	4.818477
			283 28 19.0	103 40 11.4	Soda	25122.6	4.400065
Aspen Peak	42 18 57.286	1767.6	49 23 40.7	229 07 54.2	Soda	42675.5	4.630179
1904	122 05 12.427	284.6	114 22 07.9	293 35 47.8	Onion	102819.1	5.012074
			147 40 45.0	327 30 11.8	Rust	39970.8	4.601743
Mount Pitt	42 26 41.964	1294.8	17 45 10.0	197 38 35.2	Soda	44283.2	4.646239
1904	122 18 54.365	1242.5	110 23 28.0	289 46 20.7	Onion	79960.0	4.902873
			171 22 17.4	351 16 14.7	Black	80395.0	4.905232
			172 15 27.2	352 14 09.0	Rust	19586.5	4.291956
Lost Peak[1]	42 30 50.92	1571.2	102 53 37	282 09 35	Onion	91166.2	4.959834
1904	122 08 42.90	979.3	125 19 26	305 11 14	Rust	20313.9	4.307793
Central Point astronomic station	42 23 51.581	1591.7	242 56 29.8	63 20 31.3	Rust	54593.6	4.7371413
	122 56 23.451	536.3	313 56 45.8	134 15 22.8	Soda	53065.7	4.7248137
1904							
Central Point latitude station	42 23 51.512	1589.6	116 41	296 41	Central Point astronomic station	4.77	0.6785
	122 56 23.265	532.1					
Union Peak	42 49 53.546	1652.2	23 30 40.6	203 25 35.9	Rust	25654.5	4.409163
1903	122 13 21.078	478.7	79 42 19.8	259 01 18.0	Onion	83885.9	4.923689
			157 31 38.4	337 13 58.9	Fairview	90829.7	4.958228
Mount Scott	42 55 24.019	741.2	38 57 11.5	218 43 40.3	Rust	43304.8	4.636536
1904	122 00 55.549	1259.7	75 54 57.5	255 05 26.9	Onion	102589.1	5.011101
			125 57 47.4	305 39 26.7	Black	45013.3	4.653341
Liao Rock	42 57 08.096	249.8	21 40 13.7	201 32 56.4	Rust	39734.3	4.599165
1904	122 10 06.336	143.0	71 56 52.6	251 13 35.6	Onion	91471.1	4.961284
			105 05 45.2	284 30 10.1	White	73249.6	4.864805
			134 00 04.6	313 47 59.6	Black	33351.2	4.523112
			151 00 38.6	330 40 44.3	Fairview	80652.2	4.906616
High Rock	43 03 02.950	91.0	99 58 29.9	279 35 51.2	White	45656.3	4.659501
1904	122 29 05.670	128.3	188 10 33.3	8 11 26.2	Black	12300.9	4.089936
			346 43 45.8	166 49 22.7	Rust	49196.5	4.691934
Old Bailey	43 09 19.956	615.8	58 22 56.4	237 41 39.0	Onion	97243.4	4.987860
1904	122 13 09.098	205.6	86 56 58.3	266 23 24.2	White	66684.7	4.824026
			91 38 41.9	271 28 40.6	Black	19869.5	4.298188
			143 52 40.2	323 34 49.3	Fairview	59349.0	4.773418
Walker Peak[1]	43 11 33.68	1039.4	84 13 22	263 55 55	Black	34743.1	4.540868
1904	122 02 18.18	410.5	131 31 15	311 05 56	Fairview	66233.1	4.821075

[1] No check on this position.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithm
Supplementary points—Continued.	° ′ ″		° ′ ″	° ′ ″		*Meters*	
Dodson (U. S. G. S.) 1904	43 07 10.136 123 14 35.150	312.8 794.6	127 39 24.7 207 16 30.9 269 28 35.0	307 36 20.1 27 23 52.6 89 37 01.2	Burg Scott White	7706.1 31669.4 16738.3	3.886832 4.500640 4.223711
Rose 1904	43 14 09.038 123 19 18.555	278.9 418.8	233 53 46.81 298 51 36.64	54 04 23.33 119 03 17.19	Scott White	25859.68 26426.56	4.4126232 4.4220406
Burg 1904	43 09 42.607 123 19 05.198	1314.8 117.4	177 54 02.44 221 16 38.67 281 13 40.24	357 53 53.30 41 27 05.61 101 25 11.18	Rose Scott White	8227.53 31214.99 23288.13	3.9152697 4.4943632 4.3671347
Roseburg latitude station 1904	43 12 40.769 123 21 13.849	1258.1 312.6	223 40 38.71 332 08 06.89	43 41 57.67 152 09 34.93	Rose Burg	3767.03 6218.42	3.5759994 3.7936802
Quartz 1904	43 09 51.770 122 40 14.595	1597.6 329.7	80 52 53.4 181 48 31.6 271 25 29.2	260 37 50.6 1 49 16.9 91 33 59.7	White Fairview Black	30226.3 46891.4 16866.9	4.480385 4.671093 4.227036
Diamond Peak 1904	43 31 16.014 122 08 54.659	494.2 1227.5	32 36 47.1 100 14 59.1 109 18 18.1 124 18 40.2	212 23 49.1 279 54 09.2 288 12 24.7 303 39 24.4	Black Fairview Roman Spencer	47516.3 41354.7 135233.7 91913.4	4.676843 4.616525 5.131085 4.963379
Mount Zion [1] 1903	43 47 29.576 122 43 24.335	912.8 544.1	99 42 38.7 125 41 05.6	279 00 29.5 305 25 38.8	Roman Spencer	82638.6 36682.3	4.917183 4.564457
Russian Church, cross 1908	44 03 18.487 123 10 36.088	570.6 803.2	148 04 20.1 247 32 11.5 287 52 19.2 320 26 05.3	328 03 51.0 67 39 27.3 108 01 10.6 140 29 30.3	Willamette south base Seavies 2 Pisgah Spencer	1760.8 15077.3 17895.6 10316.1	3.245722 4.178324 4.252746 4.013515
Springfield, Methodist Church 1908	44 02 53.545 123 01 20.032	1652.6 445.9	39 01 16.7 101 37 24.9 193 31 04.2	218 58 15.1 281 34 32.2 13 31 53.2	Spencer Eugene astronomic station Seavies 2	9246.3 5644.9 6701.9	3.965968 3.751653 3.826199
Springfield, Christian Church 1908	44 02 51.552 123 01 11.024	1591.1 245.4	40 13 27.9 101 49 52.3 191 43 56.5	220 10 10.0 281 46 43.3 11 44 39.2	Spencer Eugene astronomic station Seavies 2	9326.1 5853.9 6719.0	3.969699 3.767444 3.827305
Eugene, Deady Hall, west tower 1908	44 02 49.475 123 04 32.924	1527.0 732.9	135 34 35.0 221 23 39.0 12 10 13.9	315 33 56.4 41 26 42.1 192 09 26.3	Eugene astronomic station Seavies 2 Spencer	1765.3 8856.9 7222.7	3.246821 3.947284 3.858699
Eugene, Geary School spire 1908	44 03 22.161 123 06 11.803	684.0 262.7	101 29 14.4 255 22 35.7 296 45 11.7 355 10 34.6	281 25 41.5 75 23 05.8 116 50 59.3 175 10 55.8	Willamette south base Eugene astronomic station Pisgah Spencer	6952.0 997.6 12480.2 8098.6	3.842110 2.998939 4.096223 3.908378
Eugene, United Brethren Church 1908	44 02 53.966 123 05 02.786	1665.6 62.0	105 07 28.9 153 01 50.8 225 03 47.3 296 18 37.8	285 03 08.1 333 01 33.1 45 07 11.3 116 23 37.6	Willamette south base Eugene astronomic station Seavies 2 Pisgah	8648.2 1259.0 9211.4 10716.9	3.936928 3.100014 3.964328 4.030071
Eugene, Patterson School spire 1908	44 02 47.636 123 04 46.593	1470.3 1037.3	9 51 58.2 144 44 27.6 222 35 32.0	189 51 20.2 324 43 58.6 42 38 44.7	Spencer Eugene astronomic station Seavies 2	7108.8 1613.5 9102.7	3.851794 3.207756 3.959172
Eugene, Baptist Church spire 1908	44 03 05.830 123 05 19.023	179.9 423.5	103 18 42.4 164 30 09.1 228 15 28.8 297 10 01.0	283 14 32.7 344 30 02.6 48 19 04.1 117 15 11.9	Willamette south base Eugene astronomic station Seavies 2 Pisgah	8207.9 784.3 9223.0 11204.5	3.914232 2.894509 3.964873 4.049392
Engene, W. O. W. Hall spire 1908	44 03 05 553 123 05 46.259	171.4 1029.8	207 25 29.7 230 36 09.7 295 46 25.7	27 25 42.1 50 40 03.9 115 51 55.6	Eugene astronomic station Seavies 2 Pisgah	861.2 9689.2 11743.5	2.935103 3.986290 4.069796
Engene, courthouse, flagpole 1908	44 03 06.273 123 05 24.041	193.6 535.2	103 23 55.9 172 29 22.8 228 46 41.9 296 58 08.6	283 19 49.7 352 29 19.7 48 50 20.6 117 03 23.0	Willamette south base Eugene astronomic station Seavies 2 Pisgah	8096.0 748.6 9297.7 11310.2	3.908272 2.874247 3.968374 4.053471
Eugene, Methodist Church 1908	44 02 56.857 123 05 31.498	1754.8 701.2	105 41 44.6 183 46 22.9 228 07 33.9 295 16 37.7	285 37 43.6 3 46 25.0 48 11 17.8 115 21 57.2	Willamette south base Eugene astronomic station Seavies 2 Pisgah	8008.4 1035.0 9614.6 11331.3	3.903543 3.014948 3.982933 4.054279
Seavies (U. S. G. S.) [2]	44 06 31.970 122 59 54.656	986.8 1215.5	29 01 13.7 73 39 13.6	208 57 12.7 253 31 18.2	Spencer Willamette south base	15922.3 15846.5	4.202007 4.199933
Ball Butte 1903	43 58 47.550 121 41 15.765	1467.6 351.4	60 56 47.4 88 06 26.2 90 41 41.0	240 16 44.4 266 41 05.0 269 43 03.5	Fairview Roman Spencer	89125.1 164724.4 112893.8	4.950000 5.216758 5.052670

[1] No check on this position.

[2] Checked by vertical angles only.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithm
Supplementary points—Continued.	° ′ ″		° ′ ″	° ′ ″		*Meters*	
St. Mary Butte	44 05 00.402	12.4	54 34 20.3	233 54 42.2	Fairview	94533.8	4.975587
1903	121 41 54.992	1223.5	84 05 04.6	262 40 05.7	Roman	164637.6	5.216529
			84 49 15.3	263 51 01.6	Spencer	112470.9	5.051040
South Sister	44 06 14.251	439.9	51 18 35.7	230 41 52.5	Fairview	91410.3	4.960995
1903	121 46 08.254	183.6	83 00 38.4	261 38 34.5	Roman	159294.6	5.202201
			83 17 03.4	262 21 45.1	Spencer	107102.8	5.029801
			115 41 46.4	294 51 30.7	Peterson	105823.7	5.024583
Middle Sister	44 08 55.768	1721.3	48 29 01.0	227 52 52.6	Fairview	93746.9	4.971957
1903	121 46 59.750	1328.0	80 32 32.2	259 37 48.4	Spencer	100670.4	5.028044
			81 09 56.6	259 48 26.5	Roman	158846.6	5.200978
			113 27 24.0	292 37 43.2	Peterson	102708.7	5.011607
North Sister	44 10 01.464	45.2	47 57 31.4	227 20 53.1	Fairview	95803.0	4.981379
1903	121 46 17.183	381.8	79 34 17.3	258 39 03.3	Spencer	107952.1	5.033231
			80 30 32.5	259 08 32.0	Roman	160103.2	5.204400
			112 13 06.1	291 22 55.0	Peterson	102793.1	5.011964
Nebo [1]	44 09 27.05	834.9	356 25 48	176 27 50	Fairview	63596.0	4.803430
1903	122 42 05.14	114.2	58 36 38	238 20 13	Spencer	36970.6	4.567857
Herman Peak, wooded summit [1]	44 07 29.14	899.4	220 51 52	41 11 10	Mary	55978.7	4.748023
1903	124 00 43.71	971.8	316 51 55	137 03 22	Roman	32266.6	4.508753
Prairie Peak, west tree	44 16 42.307	1305.8	14 21 17.1	194 15 52.7	Roman	41958.9	4.622824
1903	123 36 28.771	638.0	190 06 28.8	10 08 50.8	Mary	23556.2	4.407496
			308 24 09.5	128 45 35.9	Spencer	52540.8	4.720497
Alsea Peak, partly cleared wooded summit	44 25 27.821	858.7	227 11 02.2	47 16 08.3	Mary	13160.6	4.119275
1904	123 40 22.746	503.1	260 03 23.6	80 33 01.0	Peterson	56896.3	4.755084
			5 12 21.3	185 09 39.5	Roman	57111.2	4.756721
Cannibal Peak, highest wooded summit [1]	44 28 33.48	1033.4	261 49 41	82 01 38	Mary	22836.9	4.358638
1903	123 50 09.03	199.6	352 48 28	172 52 35	Roman	63099.9	4.800029
Mount Washington	44 19 57.346	1770.1	38 32 25.7	217 58 29.8	Fairview	105607.3	5.023694
1903	121 50 15.638	346.5	69 20 51.5	248 28 18.8	Spencer	107781.9	5.032546
			73 35 56.4	252 16 34.7	Roman	159065.5	5.201576
			98 34 49.1	277 22 50.5	Mary	137832.6	5.139352
			102 47 18.1	281 59 49.4	Peterson	92180.5	4.964639
Hayrick	44 28 46.040	1421.1	33 29 07.0	212 55 19.5	Fairview	118610.5	5.074123
1903	121 50 31.724	701.1	61 36 02.5	240 43 36.8	Spencer	114246.8	5.057844
			68 05 14.2	246 45 57.3	Roman	164090.3	5.215083
			91 47 12.2	270 35 19.1	Mary	136000.3	5.133540
Left Nipple	44 29 49.672	1533.2	36 09 59.1	215 48 15.8	Spencer	70527.6	4.848359
1903	122 34 33.718	745.0	90 58 23.5	270 17 21.8	Mary	77591.1	4.889812
			92 54 31.7	272 37 01.5	Peterson	31223.8	4.494486
			144 40 08.0	324 16 10.6	Yam	77201.2	4.887624
Lebanon, tall brick chimney [1]	44 32 58.43	1803.6	49 46 03	229 43 21	Peterson	6694.0	3.825683
1903	122 54 14.18	313.0	84 42 42	264 15 27	Mary	51724.6	4.713697
Corvallis closed cupola [1]	44 33 59.92	1849.5	284 17 14	104 30 04	Peterson	25035.6	4.398558
1903	123 16 23.92	527.8	72 50 39	252 38 56	Mary	23160.8	4.364754
Corvallis open cupola [1]	44 33 55.89	1725.2	283 44 22	103 57 28	Peterson	25481.7	4.406228
1903	123 16 46.16	1018.6	72 46 27	252 35 00	Mary	22655.2	4.355167
Albany courthouse cupola [1]	44 38 05.82	179.6	321 24 27	141 30 17	Peterson	17662.0	4.247040
1903	123 06 24.31	535.8	67 54 06	247 35 22	Mary	38180.6	4.581843
Forest Peak, tallest trees	44 40 22.978	709.3	40 55 31.0	220 46 56.5	Mary	24714.5	4.392952
1903	123 20 52.841	1163.9	200 27 53.5	20 36 34.5	Yam	46215.9	4.664792
			237 04 37.3	57 31 29.5	Hult	59720.7	4.776125
Round Peak	44 37 52.709	1627.0	66 32 19.8	246 16 03.4	Peterson	33498.2	4.525021
1903	122 34 54.345	1197.9	80 00 05.7	259 19 15.6	Mary	78313.7	4.893838
			137 24 19.3	317 00 34.8	Yam	65297.7	4.814898
			172 28 37.1	352 21 28.2	Barnes	100397.3	5.001722
Thomas, cairn	44 38 10.938	337.6	66 11 53.3	245 55 12.3	Peterson	34431.0	4.536950
1903	122 34 19.315	425.7	79 42 15.8	259 01 01.0	Mary	79172.8	4.898576
			136 34 51.0	316 10 41.7	Yam	65412.8	4.815663
Mount Jefferson	44 40 29.156	899.9	53 50 37.1	232 56 16.5	Spencer	128789.4	5.109880
1903	121 47 55.280	1217.6	79 17 59.6	258 28 43.7	Peterson	94639.6	4.976073
			82 53 24.4	261 39 34.1	Mary	140470.1	5.147584
			112 33 05.6	291 36 11.6	Yam	114632.8	5.059309
			141 59 59.6	321 19 33.6	Barnes	120717.4	5.081770
			166 43 29.4	346 31 14.3	Larch	98063.9	4.991509
Monmouth Peak	44 47 51.810	1599.3	226 50 08.6	47 07 03.9	Yam	43124.9	4.634728
1903	123 32 31.994	703.2	254 01 14.1	74 36 21.4	Hult	68082.6	4.833036
			1 18 42.3	181 18 18.6	Mary	32556.7	4.512641
Salem Capitol, dome [1]	44 56 19.47	601.0	146 50 53	326 46 02	Yam	16434.8	4.215764
1903	123 01 43.50	953.8	263 37 32	83 50 56	Hult	25095.6	4.399597

[1] Checked by vertical angles only.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithm
Supplementary points—Continued.	° ′ ″		° ′ ″	° ′ ″		*Meters*	
Chemawa tank [1]	45 00 11.41	352.2	119 19 23	299 13 03	Yam	13485.0	4.129850
1903	122 59 36.91	808.4	281 11 15	101 23 10	Hult	22595.5	4.354021
Table Rock, cairn	44 58 14.226	439.2	62 41 39.8	241 49 11.6	Mary	111189.6	5.046064
1903	122 18 33.078	724.9	88 41 38.0	268 24 31.6	Hult	31840.9	4.502985
			99 07 35.3	278 32 12.5	Yam	66503.7	4.822846
			150 54 46.0	330 35 59.0	Barnes	70841.4	4.850287
Arquett, cairn	45 04 19.542	603.3	71 29 32.7	251 10 17.5	Hult	37746.4	4.576875
1903	122 15 32.310	706.8	89 26 06.6	268 48 33.9	Yam	69619.7	4.842732
			142 51 42.3	322 30 45.8	Barnes	63539.5	4.803044
White church spire, west of Brooks [1]	45 07 25.83	797.4	314 34 45	134 44 28	Hult	25370.3	4.404325
1903	122 56 30.05	656.7	66 46 53	246 38 20	Yam	17241.9	4.236586
Fairdale Peak [1]	45 15 09.97	307.8	307 47 30	128 09 44	Hult	52265.0	4.718211
	123 14 10.05	219.2	340 50 21	160 54 19	Yam	22381.3	4.349885
Sheridan Peak, highest green tree [1]	45 16 53.64	1655.9	301 12 17	121 43 31	Hult	67744.5	4.830874
1903	123 26 49.37	1076.0	315 24 22	135 37 19	Yam	34125.7	4.533082
Squaw, cairn	45 13 51.206	1580.8	78 12 49.8	257 25 55.7	Yam	88717.2	4.948008
1903	122 02 24.710	539.0	120 51 29.4	300 21 10.6	Barnes	64596.7	4.810210
			173 47 48.4	353 45 48.7	Larch	33800.2	4.528919
Eagle cairn [1]	45 16 25.38	783.6	118 29 55.3	298 01 22.3	Barnes	59406.9	4.773837
1903	122 04 54.19	1181.5	179 11 18.5	359 11 05.1	Larch	28844.4	4.460062
Mount Hood	45 22 27.122	837.3	73 33 10.7	252 31 35.7	Yam	118745.2	5.074616
1903	121 41 48.696	1059.6	102 00 29.2	281 15 27.4	Barnes	84113.8	4.924867
			102 50 31.3	282 07 15.7	Balch	81053.5	4.908772
			120 13 06.7	299 56 25.9	Larch	35263.2	4.547322
Fir	45 31 23.055	711.8	295 11 01.5	115 11 39.9	Cem	1293.0	3.111594
1903	122 44 46.238	1003.6	8 09 29.8	188 09 23.5	Hill	1343.7	3.128313
Monument, General Land Survey	45 31 11.933	368.4	23 58 29.5	203 58 15.0	Hill	1079.9	3.033393
1903	122 44 34.806	755.4	144 09 14.0	324 09 05.8	Fir	423.6	2.626968
Hill	45 30 39.970	1234.0	176 26 18.0	356 26 14.4	Barnes	1749.4	3.242892
1903	122 44 55.023	1194.3	240 10 43.2	60 11 27.9	Cem	1568.4	3.195468
Cem	45 31 05.230	161.5	123 20 05.0	303 19 16.7	Barnes	1758.5	3.245153
1903	122 43 52.328	1135.8	198 44 43.5	18 45 53.8	River	6640.3	3.822185
River	45 34 28.89	891.9	285 42 28.7	105 48 25.4	Rocky Butte	11258.5	4.0514797
1903	122 42 13.91	301.6	34 07 13.5	214 05 14.9	Barnes	6426.7	3.8079902
Oregonian	45 31 13.21	407.8	161 11 03.4	341 09 55.6	River	6382.8	3.8050088
1903	122 40 38.97	845.8	251 11 25.6	71 16 14.4	Rocky Butte	9273.7	3.9672517
Portland longitude station	45 31 08.82	272.3					
1887	122 40 39.75	862.7					
Portland latitude station	45 31 08.83	272.6	187 56 52	7 56 53	Oregonian	136.6	2.13537
1887	122 40 39.84	864.5					
Portland bench mark (U. S. G. S.)	45 31 09.07	280.0			Oregonian	128.7	2.10969
	122 40 39.77	863.1					
Rocky Butte (Oreg.)	45 32 49.861	1539.3	81 09 27.93	261 01 32.80	Barnes	14620.66	4.1649670
1889	122 33 54.303	1177.8	140 59 23.21	320 46 20.26	Warren	37539.95	4.5744937
			177 15 37.04	357 14 17.96	Davis	49689.84	4.6962679
Harney (Wash.)	45 37 21.734	671.0	328 15 53.08	148 18 43.96	Rocky Butte	9866.53	3.9941643
1881	122 37 53.538	1159.9	40 59 24.33	220 54 19.74	Barnes	14110.22	4.1495337
Balch (Oreg.)	45 31 54.574	1684.8	80 15 16.28	260 13 29.77	Barnes	3286.69	3.5167584
1881	122 42 30.763	667.4	210 43 44.61	30 47 02.60	Harney	11753.53	4.0701684
			261 17 15.30	81 23 23.91	Rocky Butte	11334.39	4.0543981
Vancouver Barracks flagstaff west [2]	45 37 37.91	1170.5	282 39 59.2	102 41 12.5	Harney	2276.1	3.357196
1903	122 39 36.04	781.0	32 13 36.7	212 09 45.3	Barnes	13184.2	4.120055
Warren schoolhouse cupola [2]	45 48 47.53	1467.3	345 42 09.3	165 47 36.3	Barnes	32840.1	4.516405
1903	122 51 13.32	287.6	69 43 50.8	249 43 11.1	Warren	1274.2	3.105229
Mitchell [1]	46 01 53.001	1636.4	37 55 26.5	217 31 27.4	Barnes	70902.3	4.850660
1903	122 11 31.940	687.0	65 03 28.8	244 34 18.3	Warren	58025.5	4.763619
Mount Adams	46 12 12.133	374.6	32 05 53.1	211 40 11.3	Larch	87719.5	4.943096
1903	121 29 24.899	533.8	52 09 53.4	231 17 41.3	Balch	120500.8	5.080990
			52 54 14.0	231 59 59.1	Barnes	123384.6	5.091261
			152 03 49.2	331 44 15.5	Bel	73257.2	4.864850
Mount St. Helens	46 11 53.028	1637.3	353 45 05.3	173 49 32.9	Larch	74331.7	4.871174
1903	122 11 25.864	554.5	30 24 56.9	210 00 51.4	Barnes	86336.8	4.936196
			161 21 14.0	341 09 50.7	Hal	62582.2	4.796451
			196 21 43.7	16 32 38.5	Bel	67997.0	4.832490

[1] Checked by vertical angles only.

[2] No check on this position.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithm
Supplementary points—Continued	° ′ ″		° ′ ″	° ′ ″		*Meters*	
Min	46 18 55.031	1699.2	36 54 48.26	216 54 40.53	Len	380.7	2.5805528
1906	122 07 49.822	1066.0	195 35 51.98	15 44 10.73	Bel	54196.2	4.7339685
Deschutes Peak	46 39 25.252	779.8	141 03 59.3	321 00 10.8	Hal	10607.4	4.025608
1905	122 21 54.262	1153.7	166 44 01.2	346 37 33.9	Hurst	48784.1	4.688278
			246 15 51.1	66 34 26.0	Bel	35486.1	4.550058
Mineral Peak	46 38 56.26	1737.2	150 54 20	330 38 47	Hurst	55420.9	4.743674
1905	122 09 27.44	583.5	227 45 19	47 54 50	Bel	22481.8	4.351832
High Rock	46 41 05.848	180.6	97 08 52.2	276 44 46.4	Hal	42506.0	4.628450
1905	121 54 01.859	39.5	133 47 15.3	313 20 27.1	Hurst	64374.5	4.808714
			164 54 33.5	344 52 50.9	Bel	11486.7	4.060194
Goat Mountain	46 46 23.948	739.5	83 54 43.7	263 30 26.2	Hal	42726.6	4.630698
1905	121 53 47.263	1002.8	111 01 08.5	290 59 15.1	Bel	3535.4	3.548435
Mount Ranier, high peak	46 51 09.215	284.5	75 59 36.2	255 29 12.0	Hal	54766.4	4.738514
1905	121 45 25.562	541.5	114 23 27.3	293 50 19.5	Hurst	62984.3	4.799232
Mount Ranier, bare summit	46 51 11.106	342.9	75 48 48.0	255 18 39.5	Hal	54339.9	4.735119
1905	121 45 47.001	995.7	114 30 34.9	293 57 42.7	Hurst	62546.5	4.796203
Sharp Peak	47 01 04.392	135.6	8 27 57.5	188 25 44.7	Bel	26205.4	4.418390
1905	121 53 20.964	442.8	53 37 01.4	233 12 21.8	Hal	53466.3	4.728080
			99 03 14.7	278 35 52.2	Hurst	47932.2	4.680627
Tacoma City Hall	47 15 28.463	879.0	177 53 26.9	357 53 20.8	Dron	4708.1	3.672844
1905	122 26 20.264	426.0	187 00 33.5	7 00 52.6	Gull	4484.0	3.651667
			257 03 27.6	77 05 53.5	Bos	4285.2	3.631972
			326 42 26.2	146 43 27.2	Kin	3182.3	3.502746
Tacoma courthouse	47 15 12.780	394.7	122 44 24.8	302 42 41.3	Wash	3519.8	3.546524
1905	122 26 43.527	915.2	191 51 19.7	11 51 55.9	Gull	5042.5	3.702643
			314 12 45.2	134 14 03.3	Kin	3119.9	3.494135
Smelter stack, 300 feet high	47 17 51.813	1600.1	196 41 00.6	16 41 40.6	Neill 2	3972.1	3.599017
1905	122 30 23.274	489.0	247 07 19.4	67 10 45.5	Dash	6390.9	3.805562
			331 07 48.6	151 08 46.6	Wash	3435.1	3.535934
Brown Point Lighthouse	47 18 23.031	711.3	38 04 48.2	218 02 59.4	Wash	5045.6	3.702914
1906	122 26 36.330	763.2	128 05 49.9	308 03 43.0	Neill 2	4605.8	3.663308
			169 04 31.7	349 04 03.4	Piner 2	4271.9	3.630626
Dash	47 19 12.171	375.9	37 39 18.36	217 36 50.30	Wash	6932.54	3.8408923
1857	122 25 42.896	901.0	105 35 50.58	285 33 04.37	Neill 2	4928.00	3.6926708
Piner 2	47 20 38.852	1199.9	324 10 34.26	144 11 41.91	Dash	3301.11	3.5186600
1905	122 27 14.898	312.8	15 44 13.69	195 42 53.22	Wash	8484.54	3.9286282
			64 19 31.98	244 17 53.39	Neill 2	3123.19	3.4945984
Robinson 2	47 23 11.720	362.0	28 27 36.29	208 25 15.86	Dash	8413.28	3.9249652
1867	122 22 31.984	670.9	51 32 05.89	231 28 37.75	Piner 2	7584.71	3.8799391

DESCRIPTIONS OF STATIONS.

This list may be conveniently consulted by reference to the illustrations at the end of this publication or to the index. All azimuths given in these descriptions are reckoned continuously from true south around by west to 360°, south being 0°, west 90°, north 180°, and east 270°. Where magnetic azimuths are given they are indicated as such.

In general the surface and underground marks are not in contact, so that a disturbance of the surface mark will not necessarily affect the underground mark. The underground mark should be resorted to only in cases where there is evidence that the surface mark has been disturbed.

The dates and initials given in each description immediately after the county refer to the date of establishment of the station, the man by whom it was established, and the date when the station was last visited.

Any person who finds that one of the stations herein described has been disturbed, or that the description no longer fits the facts, is requested to send such information to the Superintendent, U. S. Coast and Geodetic Survey, Washington, D. C.

MARKING OF STATIONS.

The old type of station mark referred to in the following notes and descriptions consists of a disk and shank made of brass and cast in one piece. The disk is about 85 mm. in diameter

and has a polished center surrounded by the raised letters "U. S. C. & G. S." and a raised flange around the edge. The shank is 25 mm. in diameter and 75 mm. long, with a slit at the lower end into which a wedge is inserted so that when it is driven into a drill hole in the rock, it will bulge at the bottom and so hold the mark securely in place.

GENERAL NOTES IN REGARD TO STATION MARKS.

NOTE 1.—A three-eighths-inch copper bolt 3 inches long is cemented into a drill hole in the rock, and directly above the bolt in the same drill hole is cemented an old-type station mark, described in the preceding paragraph. A cross in the top of the copper bolt and another in the polished center of the disk mark the station.

NOTE 2.—This marking is similar to that described in note 1, except that the copper bolt and the disk are in separate bowlders and the bowlder containing the bolt is at some distance beneath the surface. The cross on the disk is directly above the one on the bolt. The dimensions of the bowlders are given in the description of the station.

NOTE 3.—The station is marked by an old-type station mark, described above, cemented into a drill hole in the rock. No underground mark was used.

REFERENCE MARK.

NOTE 4.—This mark is a drill or punch hole in the top of a three-eighths-inch copper bolt 3 inches long, which is leaded or cemented into a drill hole in a rock with the top of the bolt flush with the surface.

PRINCIPAL POINTS.

Mount Helena (Napa County, Cal., W. E., 1876; 1908).—On the summit of Mount Helena, about 12 miles to the northward of Calistoga. The station was originally marked by a fine drill hole and cross in the top of a one-half-inch copper bolt 5 inches long, which was cemented in a drill hole in bedrock, and by a brick pier 3 bricks square and 43 inches high, built over the bolt. When visited in 1908 it was found that the pier had been dynamited. Other instrument piers are at the following distances and directions from the station: Collimator pier, 2 bricks square and 61 inches high, 2.27 meters northwest; transit pier, 2 by 3 bricks and 39 inches high, 17.04 meters southwest; latitude pier, 2 by 2½ bricks and 36 inches high, 17.74 meters southwest of the station and 1.68 meters east of the transit pier; vertical angle pier, 2 bricks square and 44 inches high, 33.31 meters southwest of the station and 16.92 meters a little south of east of the latitude pier. A boundary mark between Lake and Napa Counties, a large drill hole in a basaltic rock, is 2.18 meters northwest of the station.

Marysville Butte (Sutter County, Cal., W. E., 1876; 1904).—About 15 miles west of Marysville on the southeastern summit of the south butte of the Marysville Buttes, about 6 meters northeast of the highest part of the summit, and near the steep cliff on the north side. The station is marked by an old-type station mark, described on page 42, set in a drill hole in a small rock embedded in the concrete that fills a depression in the solid rock. Below the concrete and directly under the station mark is a three-eighths-inch copper bolt 3 inches long set in a drill hole in the solid rock. Three reference marks, each of which is a three-eighths-inch copper bolt 3 inches long set in a drill hole in the rock, are at the following distances and azimuths from the station: 2.470 meters, 246° 48′; 2.635 meters, 5° 06′; and 2.915 meters, 103° 07′.

Snow Mountain west (Glenn and Lake Counties, Cal., E. F. D., 1892; 1904).—On the highest point of the southwest summit of Snow Mountain. The summit is about 300 meters long in a northwest and southeast direction and about 50 meters wide at the station and is covered with small broken stones. There are a few scrub pines just below the pitch of the ridge about 100 meters southeast of the station. The station is marked by a one-half-inch brass bolt 3 inches long in a drill hole in the solid outcropping rock, and by a concrete pier 12 inches square and 44 inches high having embedded in its top a brass bolt directly above the one in the solid rock.

Snow Mountain east (Glenn County, Cal., W. E., 1876; 1904).—On the northernmost rock-croppings at the edge of the summit of the eastern peak of Snow Mountain, about 5 miles south of Mount St. John and near the corner of Lake, Colusa, and Glenn Counties. The station is marked by a half-inch copper bolt cemented in a drill hole in a hollow at about the middle of the highest point of rocks, with the top of the bolt about a half inch above the surface and marked by a cross. The reference marks are all drill holes in rocks, the first being distant 5.16 meters in azimuth 59° 57′, the second 3.33 meters in azimuth 165° 39′, and the third 6.89 meters in azimuth 248° 38′.

Kent (Tehama County, Cal., O. B. F., 1904).—On a high ridge about 8 or 10 miles east by south from Mount Linn and about 18 miles by road in a northwesterly direction from Paskenta, on a peak locally known as Bald Rock, on a ledge on the east side of the summit and about 8 or 9 feet lower than its highest part. Four or five hundred feet to the westward of the station and about 50 or 60 feet lower is a large, prominent, rocky knob. The station is marked according to note 1.[1] The reference marks are described in note 4.[1] The first one is in a large rock distant 5.01 meters in azimuth 212° 40′, the second in a flat ledge distant 70.19 meters in azimuth 285° 50′, and the third on the largest part of the ledge distant 47.72 meters in azimuth 5° 17′.

Lyons (Tehama County, Cal., O. B. F., 1904).—About 5 miles east of Lyonsville post office on a ridge known locally as Bald Hill, about 300 yards from the summit of the ridge on the shoulder extending toward Lyonsville and in the middle of a large group of bowlders. A lone fir tree stands about 50 meters south by east from the station. The station is marked according to note 1.[1] Two reference marks described in note 4,[1] are in large rocks and at the following distances and azimuths from the station: 29.69 meters, 126° 59′; and 20.22 meters, 332° 22′.

Bally (Shasta County, Cal., O. B. F., 1904).—On the northernmost of the two main peaks on the summit of Bally Mountain, a prominent and well-known mountain about 15 miles by road west of Redding. The station mark, described in note 1,[1] is in the top of a rock on the north side of the most prominent group of rocks on the peak and 5 or 6 feet below the top of the group. Two reference marks, described in note 4,[1] are at the following distances and azimuths from the station: 4.29 meters, 247° 07′; and 10.62 meters, 154° 49′.

Round (Shasta County, Cal., O. B. F., 1904).—On the highest part of what is known as Round Mountain just north of the post office of the same name. The station mark, described in note 1,[1] is in a large bowlder which projects about 6 inches out of the ground. Two reference marks, described in note 4,[1] are at the following distances and azimuths from the station: 28.72 meters, 345° 30′; and 6.43 meters, 57° 13′. The south reference mark is in the most eastern rock of a prominent group of rocks near the south end of the summit.

Spur (Siskiyou County, Cal., O. B. F., 1904).—On the west slope of Mount Shasta at an elevation of about 9,100 feet, in a position best identified by approaching the summit from Igema, by the road leading through Kite Canyon. In ascending this route several prominent peaks are discerned ahead and from the right-hand one a narrow shoulder extends in a westerly direction, or toward Black Butte. The station is about 50 meters below an abrupt change of slope of the ridge of this shoulder, and about 1 mile from the peak mentioned above. The station mark, described in note 1,[1] is in the top of a large rock flush with the ground. Two reference marks described in note 4,[1] are at the following distances and azimuths from the station: 13.77 meters, 165° 53′; and 8.10 meters, 228° 47′.

Mears (Shasta County, Cal., O. B. F., 1904).—About 4 or 5 miles west by south from Castella and about southwest from Castle Crags, on the southern summit of the highest rocky peaks in the region known locally as Gray Rocks. The station is about 20 feet below the highest part of the peak and near the bluff on the south and east sides, with a ledge 3 or 4 feet higher about 10 feet distant toward the southeast. The peak was approached from the south and the 30-foot bluff near the station surmounted by means of ladders. The station

[1] See p. 43.

is marked according to note 1.[1] Two reference marks, described in note 4,[1] are located as follows: The first in a bowlder near the trail to the station, and distant 7.92 meters in azimuth 70° 50′; and the second, on a low bowlder east of a high pointed rock, and distant 17.77 meters in azimuth 143° 03′.

Boliver (Siskiyou County, Cal., O. B. F., 1904).—On the north side of a large group of bowlders about 60 yards northeast of the highest part of the summit of Mount Scott, known locally as Old Craggy or Boliver, which is the high peak about 5 miles in a southerly direction from Callahan. The station is marked according to note 1.[1] Two reference marks, described in note 4,[1] are at the following distances and azimuths from the station: 6.57 meters, 272° 41′; and 9.88 meters, 107°, 47′.

Soda (Jackson County, Oreg., O. B. F., 1904).—On a peak known locally as Old Baldy, in the Siskiyou range of mountains, about 20 miles by road and trail southeast of Ashland and 5 miles east by north from Pilot Rock, a prominent peak in the same range. The best approach is from Ashland via Soda Springs and Davis' ranch. The station mark, described in note 1,[1] is in a large rock whose upper surface is flush with the ground. Two reference marks, described in note 4,[1] are in bowlders whose tops are but slightly above ground and at the following distances and azimuths from the station: 12.91 meters, 299° 53′; and 23.95 meters, 35° 36′.

Gazelle astronomic station (Siskiyou County, Cal., O. B. F., 1904; 1908).—About 250 yards north by east from the Gazelle railroad station near the center of the top of a very prominent knoll and about 40 feet northeast of the largest bowlder on the knoll. The station mark, described in note 1.[1] is in a rock below the surface of the ground. Three reference marks, described in note 4,[1] are at the following distances and azimuths from the station: 19.20 meters, 290° 12′; and 6.40 meters, 137° 39′.

Sterling (Jackson County, Oreg., O. B. F., 1904).—In the Siskiyou range of mountains, about 25 miles southwest of Ashland and 2 miles west of Mount Sterling, on the northernmost summit of a ridge just south of the Silver Fork basin and at the western end of the long east-and-west valley which is just north of Mount Sterling. The station is about 80 or 90 meters southeast of the highest point of the summit in the center of a group of small bowlders. The station mark, described in note 1,[1] is in the top of a large rock. Two reference marks, described in note 4,[1] are at the following distances and azimuths from the station: 34.85 meters, 18° 13′; and 20.44 meters, 136° 03′.

Rust (Jackson County, Oreg., O. B. F., 1904).—On the highest summit of the peaks known locally as the Black Buttes (Rustler on U. S. Geological Survey maps), about 20 miles north of Mount Pitt and 26 miles by road and trail from Big Butte post office via Parker's ranch. The station is marked according to note 1.[1] Two reference marks, described in note 4,[1] are at the following distances and azimuths from the station: 11.995 meters, 264° 33′; and 10.12 meters, 337° 53′.

Onion (Douglas County, Oreg., O. B. F., 1904).—On the highest part of the bare summit of Onion Springs Mountain, about 1 mile south of the Onion Springs, and best reached from Glendale via Galesville and Gilpatrick's ranch. The station mark, described in note 1,[1] is in a rocky ledge. Two reference marks, described in note 4,[1] are located as follows: One in a prominent ledge and 24.62 meters from the station in azimuth 91° 50′, and the other in an inconspicuous, low bowlder at the western edge of the summit and distant 47.22 meters in azimuth 182° 47′.

Black (Douglas County, Oreg., O. B. F., 1904).—Near the northeast corner of the highest part of the summit of Black Rock, a high, prominent, rocky peak about 40 miles in a direct line east of Roseburg and north and northwest of some near-by higher wooded peaks. The station mark, described in note 1,[1] is in the solid rock of the summit. Two reference marks, described in note 4,[1] are also in solid rock and at the following distances and azimuths from the station: 13.78 meters, 4° 55′; and 6.47 meters, 297° 45′.

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[1] See p. 43.

White (Douglas County, Oreg., O. B. F., 1904).—On the highest part of the summit of White Rock, a prominent peak about 15 miles east of Roseburg. The station mark, described in note 1,[1] is in a large bowlder. A reference mark, described in note 4,[1] is in a large bowlder just east of a prominent ledge and is 34.44 meters from the station, in azimuth 353° 11′.

Scott (Douglas County, Oreg., O. B. F., 1904).—On the highest part of the summit of Mount Scott, about 20 miles northeast of Roseburg. The station mark, described in note 1,[1] is in a large bowlder. Two reference marks, described in note 4,[1] are located as follows: One in a white rock at about the middle of a prominent ledge and 32.71 meters from the station in azimuth 195° 02′; and the other in a rocky ledge near the edge of the brush and 18.17 meters distant in azimuth 305° 42′.

Fairview (Lane County, Oreg., O. B. F., 1904).—On the west side of the summit of Fairview Peak in the Bohemia Mountains, about 25 miles southeast of Cottagegrove and 6 miles by road from Mineral post office. The station mark, described in note 1,[1] is in a bowlder. Three reference marks described in note 4,[1] are in rock ledges and at the following distances and azimuths from the station: 6.69 meters, 74° 29′; 2.92 meters, 181° 39′; and about 175 feet, 266° 09′.

Yellow (Douglas County, Oreg., O. B. F., 1904).—On the highest summit of the timbered ridge about 10 miles west of Yoncalla. The station is marked according to note 2,[1] the subsurface mark in a bowlder 8 by 12 by 16 inches placed 18 inches beneath the surface, and the surface mark in a bowlder 10 by 20 by 30 inches, the top of which is flush with the surface of the ground. A reference mark, described in note 4,[1] is in a rock ledge and 22.62 meters from the station in azimuth 334° 37′. Two other reference marks, consisting of three-sixteenths inch copper wires 3 inches long set in bowlders, are at the following distances and azimuths from the station: 21.04 meters, 197° 31′; and 20.70 meters, 107° 02′.

Spencer (Lane County, Oreg., O. B. F., 1903).—This station is near a United States Geological Survey station. It is on the south end and highest point of the summit of Spencer Butte, about 4 miles south of Eugene. Two trees used by the Geological Survey are at the north end of the summit, which is in the form of a ridge. The station is marked according to note 1.[1] Two reference marks, described in note 4,[1] are in rocks near the station, one distant 5.338 meters in azimuth 175° 02′, and the other 4.570 meters in azimuth 328° 51′. The Geological Survey station is 7.970 meters from the station in azimuth 176° 12′.

Roman (Douglas County, Oreg., O. B. F., 1903; 1908).—On the most westerly of the two summits of the highest peak of the Coast Range, known as Roman Nose or Saddle Mountain, situated near the north line of Douglas County about 5 miles southwest of the junction of Wild Cat Creek with the Siuslaw River. It is on the highest point of the summit, about 6 feet from the southern edge of the bluff and 20 feet from the steep part of the slope east of the station. The peak is bare except for a few low shrubs, and has a steep bluff on the south side and a gentle grassy slope on the north side. The station is marked according to note 2,[1] the subsurface mark in a bowlder 12 by 12 by 24 inches, 18 inches below the surface, set with the axis east and west, and the surface mark in a bowlder measuring about a foot on each side. Two reference marks, described in note 4,[1] are located as follows: One in the nearest outcropping of the solid rock 14.760 meters from the station in azimuth 148° 06′, and the other in a projecting bowlder 6.775 meters from the station in azimuth 205° 33′. Arrows pointing to the reference marks are cut in the rock near each mark. An old burned stump is about 5 feet from the station in azimuth 232°.

Mary (Benton County, Oreg., O. B. F., 1903; 1908).—On the highest point of the grassy summit of Mary Peak, about south-southwest from Corvallis. The station is marked according to note 2,[1] the subsurface mark in a flat stone 4 inches thick and 19 inches in diameter 22 inches below the surface, and the surface mark in a bowlder 16 by 18 by 30 inches, the top of which is flush with the surface of the ground. Two reference marks, described in note 4,[1] are in bowlders, and at the following distances and azimuths from the station: 13.77 meters, 326° 22′; and 29.36 meters, 58° 11′.

[1] See p. 43.

Peterson (Linn County, Oreg., O. B. F., 1903).—About 4 miles southwest of Lebanon on the highest part of the most westerly of the two summits known as Peterson Butte. The station is marked according to note 1.[1] Two reference marks, described in note 4,[1] are located as follows: One in the lower part of the northerly sloping face of the largest rock on the south side of the summit, and 4.645 meters from the station in azimuth 7° 30′; and the other in the ledge just east of the largest rock on the north side of the summit, and 3.270 meters distant in azimuth 185° 00′.

Twin (Linn County, Oreg., O. B. F., 1905).—On the farm of Mr. Gentry near the southwest corner of sec. 24, T. 14, R. 3 W., about 6 or 7 miles from Rowland. It is on the highest summit of a partly wooded ridge, the south slope being bare and the north slope wooded, and about 8 or 10 meters southeast of the highest point of the summit. The station is marked according to note 2,[1] the underground mark in a stone about 2 feet below the surface and the surface mark in a large stone about 6 inches below the surface. Three reference marks, described in note 4,[1] are at the following distances and azimuths from the station: 6.66 meters, 314° 42′; 6.39 meters, 53° 57′; and 6.87 meters, 155° 44′. The last-mentioned reference mark is near the highest point of the summit.

Ridge (Lane County, Oreg., O. B. F., 1905).—On the highest part of a ridge on land owned by Mr. J. J. Winn, about 1½ miles north of his residence, and about 10 miles by road in a northwesterly direction from Junction City. The station is marked according to note 2,[1] with the subsurface mark 1.5 feet below the surface. Three reference marks, described in note 4,[1] are in inconspicuous bowlders flush with the surface of the ground, and at the following distances and azimuths from the station: 4.86 meters, 164° 32′; 30.69 meters, 278° 43′; and 9.73 meters, 356° 15′. A triangular blaze in a large maple tree is 11.63 meters from the station in azimuth 92° 16′, and a similar blaze in a large fir tree is 8.45 meters distant in azimuth 213° 33′.

Rauch (Lane County, Oreg., O. B. F., 1903).—About 12 miles west by south from Eugene, 2½ miles southwest of Llewellyn post office and about one-half mile west of the road leading from Llewellyn to Crow post office, on land belonging to Mrs. Frances Rauch. It is about 150 meters east of the summit on the north side of a sloping ridge about 300 feet higher than the valley through which the road runs, the first prominent ridge encountered in going from Llewellyn to Crow and the only ridge in the vicinity from which Willamette south base can be seen. The station is about 200 feet west of a point where the ridge becomes steeper. The station was marked according to note 2,[1] the underground mark in a small flat stone 2 feet below the surface and the surface mark in a rock about 12 by 12 by 18 inches flush with the surface. Two reference marks, described in note 4,[1] are located as follows: One in a rock 10 by 10 by 18 inches on the highest part of the ridge and 11.96 meters from the station in azimuth 286° 02′, and the other in a rock 6 by 8 by 14 inches distant 12.22 meters in azimuth 51° 46′.

Willamette south base (Lane County, Oreg., O. B. F., 1903; 1908).—About 5 miles from Eugene and 220 meters south of the Eugene-Elmira road on land belonging to William Nelson. It is about 100 meters north of a large gravel pit, 78 meters from the line fence between William Nelson and M. Nelson, and about in line with the west face of the barn belonging to William Nelson which is 86.79 meters north of the station. The station is marked with old-type station mark described on page 42, placed in the center of a 6-inch drain tile and both embedded in a pillar of concrete 2 feet long, 36 inches in diameter at the base, 18 inches in diameter at the top, and set in the ground so that the tops of the pillar and tile and station mark are all flush with the surface of the ground. Six inches below the foot of this pillar a cross in the top of a ½-inch copper bolt, embedded in a block of concrete 10 by 24 by 24 inches, forms the subsurface mark. In 1906 a concrete pillar 2½ feet high, 18 inches square at the base and 12 inches square at the top, with the letters "U. S. C. S." on the south side, was set over the surface mark. The first reference mark is a ½-inch copper bolt in a concrete block 12 by 12 by 18 inches, the top of which is flush with the ground with a similar block and bolt directly beneath it as subsurface mark, distant 212.29 meters from the station in azimuth 177° 32′ 02″. The second mark, similar to the first, is at the junction of the road fence and that dividing the farms of

[1] See p. 43.

William Nelson and M. Nelson, and 225.16 meters from the station in azimuth 200° 19′ 30″. The third reference mark, similar to the preceding two but with no subsurface mark, is in the line of the boundary fence 78.38 meters from the station in azimuth 265° 16′ 42″. The fourth mark is a ½-inch copper bolt leaded into a drill hole in a large stone in the southwest corner of the foundation of the main part of William Nelson's barn, and is 86.79 meters from the station in azimuth 181° 30′ 16″.

Willamette north base (Lane County, Oreg., O. B. F., 1905; 1908).—One and one-half miles south and one-half mile west of Junction City in the east center of sec. 7, T. 16, R. 4 W., on land owned by Mr. William M. Pittney of Junction City. It is in the northeast corner of a field on the south side of the main east-and-west road, about 71 yards from the north-and-south fence to the east and 4 or 5 yards from the fence on the south side of the road, and almost opposite the main gate which leads into the barnyard corral of the farm across the road. The subsurface station mark is a three-eighths inch copper bolt 6 inches long, set in a block of concrete 3½ by 4 feet and 10 inches deep, placed 3 feet below the surface. The surface mark is an old-type station mark described on page 42, set in the top of a concrete pier 3½ feet square at the base, 1½ feet square at the top, and 2 feet 5 inches deep, the top of which is flush with the surface of the ground. Surrounding the station mark and embedded in the concrete is an 8-inch drain tile 1 foot long with its rim about flush with the top of the pier. Each of the three reference marks consists of two three-eighths inch copper bolts, 3 inches long, each set in the top of a concrete post 1 foot square, the subsurface post being 9 inches long and 2½ to 3 feet below the surface, and the surface mark about 2 feet long, with its top 4 inches below the surface,. The first reference mark is 6 inches south of the fence on the south side of the road and about in the prolongation of the fence line on the west side of the corral mentioned above, and is 32.058 meters from the station in azimuth 97° 10′. The second mark is in the corral across the road, about 10 inches from the road fence and 6 or 8 feet east of the east end of the main road gate, and is 19.876 meters from the station in azimuth 186° 24′. The third mark is on the south side of the main road, 12 or 15 feet from the road fence, and 6 inches west of the north-and-south fence, at a distance from the station of 65.076 meters in azimuth 271° 26′.

Seavies 2 (Lane County, Oreg., W. H. B., 1908).—In the same locality as *Seavies* (*U. S. G. S.*). (See p. 56.) It is on the south slope of the peak near the lower edge of the first timber from the top and almost in line with *Spencer* (see p. 46) and the tangent line to the west bank of the McKensie River at the big curve in the flat below the station. The station is marked by a drill hole in the rock and by piles of rock around the tripod erected at the station.

Pisgah (Lane County, Oreg., W. H. B., 1908).—Located north and east from Goshen on a hill known as Mount Pisgah, about 200 feet southwest, or toward Spencer Butte, from the highest point of the hill. The station is on top of a rock about 4 by 6 feet in area, projecting 16 inches above the ground, the largest one of a cluster of rocks and, with the exception of a large rock on the west slope about 175 feet to the north, the largest rock in the vicinity. Station is marked by a one-half inch drill hole 1¼ inches deep, 6 inches from the west edge of the rock and 23 inches from its south point.

Eugene astronomic station (Lane County, Oreg., O. B. F., 1904; 1908).—This station is identical with the United States Geological Survey station. It is on the east end of Skinners Butte, near Eugene, Oreg., just above the reservoir and north of the railroad station, on the site of the old observatory of Oregon State University. It was learned in 1908 that the land was to be converted into a park and that the station would be demolished, so two marble reference stones, projecting 2 inches above the surface and bearing on the top the letters "U. S." with a cross between, were set to preserve the station. The first 5 by 5 by 18 inches is 18.294 meters from the station in azimuth 119° 59′, and the second, 4 by 7 by 14 inches in size is on the south brow of the hill 12.211 meters from the station in azimuth 52° 47′. A large concrete "O" on the brow of the hill overlooking the railroad station is in azimuth 2° from the station. The distance between the two reference marks is 17.625 meters, and from the first reference mark the Patterson School spire is in azimuth 315° 28′, and the spire of the Humphrey Memorial Methodist Church is in azimuth 353° 53′.

Yam (Polk County, Oreg., O. B. F., 1903; 1908).—On the highest point of the highest of a group of hills about 12 miles northwest of Salem, and about 10 meters south of a wire fence which passes over the summit. A slightly lower wooded hill is about a half mile northwest of the station and a group of hills is about halfway between the station and Salem. The station is marked according to note 2,[1] the surface mark in a bowlder 15 by 18 by 18 inches with its top flush with the surface of the ground, and the subsurface mark in a bowlder 8 by 16 by 16 inches and 23 inches below the surface mark. Two reference marks, described in note 4,[1] are in bowlders about 14 by 18 by 18 inches with their tops flush with the surface of the ground, and with a few loose stones piled about them for identification. One is in the line of the wire fence, 11.06 meters from the station in azimuth 197° 10′, and the other 8.59 meters from the station in azimuth 329° 07′.

Hult (Marion County, Oreg., O. B. F., 1903).—On a prominent bare hill about 6 miles by road and 4 miles in a straight line southeast of Silverton, just south of the road from Silverton to Hult post office and on the farm of Ai Porter. It is on the northeast side of the hill and slightly lower than the summit, 17 feet from a line fence on the west, and 8 feet from another fence on the south. The surface and underground marks at this station are crosses cut in the tops of one-half inch copper bolts embedded in bowlders, the underground mark being in a bowlder about 12 by 14 by 14 inches, with its top 1.9 feet below the surface mark, which is in a bowlder about 14 by 18 by 24 inches, with its axis north and south. Two reference marks, described in note 4,[1] are located as follows: One in a bowlder about 14 by 16 by 16 inches, set in the fence line 5.79 meters from the station in azimuth 108° 55′, and the other in a bowlder about 14 by 16 by 24 inches, set in the fence line 7.125 meters from the station in azimuth 304° 40′.

Barnes (Multnomah County, Oreg., O. B. F., 1903).—On a cleared hill about 4 miles west of Portland, between the Barnes and Cornell roads, and just east of the highest hill in this range which hill is still densely wooded. It is on the south edge of the hill about 100 feet southeast of a fir tree and some small maple trees, and close to the north side of a large stump. The station is marked according to note 2,[1] the surface mark in a stone 8 by 14 by 18 inches with its top flush with the surface of the ground, and the subsurface mark in a stone 6 by 12 by 18 inches 1¼ feet below the surface mark. Two reference marks, described in note 4,[1] and set at the roots of stumps on the sides facing the station are located as follows: One in a bowlder 15 inches in diameter, distant 15.80 meters from the station in azimuth 156° 11′; and the other in a bowlder 12 inches in diameter 7.02 meters from the station in azimuth 233° 23′. A third reference mark consists of a cross in the top of a bowlder 10 inches in diameter buried 15 inches beneath the surface and of a copper bolt directly above the cross, in a bowlder 14 by 14 by 18 inches set with its top flush with the surface of the ground. It is about 3 feet north of the main east-and-west fence line, about 30 feet east of where this fence crosses the highest part of the ridge, about 3 feet east of a fence extending northward from this fence and 44.95 meters from the station in azimuth 184° 35′.

Larch (Multnomah County, Oreg., O. B. F., 1903).—Southeast of Bridal Veil, a town on the Columbia River, on the highest peak of Larch Mountain and on the west point of a small rock ledge which is on the north end of a spur from the main summit. The ledge is about 20 feet higher than the spur of which it forms the end, and descends abruptly on the north in a cliff about 100 feet high. It can be reached either from Bridal Veil or Latourell via Donahue's logging camp. The station is marked according to note 1.[1] Two reference marks, described in note 4,[1] are in the east summit of the ledge, one in rather a low place 10.89 meters from the station in azimuth 298° 51′, and the other near the east end of the summit 15.01 meters from the station in azimuth 287° 02′.

Star (Clark County, Wash., J. S. H., 1906).—On the most southerly of the two summits of Silver Star Mountain, on the line between Clark and Skamania Counties, about 35 miles northeast of Vancouver. The station was marked according to note 3.[1] Two reference marks, described

[1] See p. 43.

in note 4,[1] are at the following distanees and azimuths from the staeion: 5.910 meters, 305° 43′; and 5.160 meters, 26° 11′.

Davis (Cowlitz County, Wash., J. S. H., 1906).—About 14 miles northeast of Woodland on the highest point of a hill on a north-and-south ridge whieh may be reaehed from Woodland by following the road up the Lewis River to the Fisher plaee and paeking from there. The station is marked aeeording to note 3.[1] Two reference marks, deseribed in note 4,[1] are at the following distanees and azimuths from the station: 5.61 meters, 15° 02′; and 5.37 meters, 96° 51′.

Red (Skamania County, Wash., J. S. H., 1906).—On the highest point of a bald, red hill near the sourees of the Little White Salmon and Lewis Rivers and not far from Kliekitat Pass. It is best reaehed from White Salmon on the Columbia River via Guler post office, Ice Cave, Peterson's prairie, Goose Lake, Steamboat Lake, and the Indian race traek, being about 1 mile southwest from the last plaee and 1½ miles west of Steamboat Lake. The station is marked aeeording to note 3.[1] Two referenee marks, described in note 4,[1] are at the following distanees and azimuths from the station: 7.400 meters, 96° 14′; and 5.422 meters, 188° 46′.

Warren (Columbia County, Oreg., O. B. F., 1903).—About a mile southwest of Warren, a station on the Northern Pacific Railway, on a slight elevation or ridge near the west side of a pasture owned by Mr. E. Harnes and about 250 meters north of an east-and-west road. The station is marked aeeording to note 2,[1] the surfaee mark in a bowlder 8 by 24 by 24 inehes with the letters "U. S." eut in the north side and the subsurfaee mark in a stone 6 by 12 by 18 inehes buried 18 inehes below the ground. Three referenee marks, deseribed in note 4,[1] are in the north-and-south fence line to the west of the station. The middle referenee mark of the three is 246.7 meters north of the north road fenee and the other two are eaeh about 30 meters distant from the middle mark, one north and the other south. They are at the following distanees and azimuths from the station: 23.67 meters, 93° 15′; 37.46 meters, 41° 26′; and 37.95 meters, 142° 46′.

Lam (Cowlitz County, Wash., J. S. H., 1906).—On the highest part of the heavily wooded summit of Elk Mountain, about 35 miles northeast of Woodland. The station is marked aceording to note 3.[1] Two reference marks, deseribed in note 4,[1] are at the following distances and azimuths from the station: 6.28 meters, 36° 56′; and 10.84 meters, 319° 02′.

Len (Skamania County, Wash., J. S. H., 1906).—In the northwestern part of Skamania County, about 10 miles north of Mount St. Helens and a short distanee northeast of Spirit Lake. Spirit Lake ean be reaehed by stage road from Castle Rock via Toutle and St. Helens, and from the south landing on this lake the peak on whieh the station is located appears as a rocky summit through a gap almost due north. The station is marked aeeording to note 3.[1] Two referenee marks, deseribed in note 4,[1] are at the following distanees and azimuths from the station: 3.260 meters, 215° 15′; and 12.220 meters, 138° 04′.

Toutle (Cowlitz County, Wash., O. B. F., 1905).—On the top of a eonieal hill, the highest point of a long ridge, known loeally as Gum Mountain, between the north and south forks of the Toutle River and about 20 miles east of Castle Roek. The summit was heavily timbered in 1905 and lines of sight were eleared. The station is reaehed from Castle Roek via Toutle and St. Helens and the main road left at a point about 2½ miles east of St. Helens at Muniker's plaee, from where the station is about 3 miles distant in a southerly direetion. The station is marked aceording to note 2,[1] the underground mark in a stone 12 inches in diameter 2 feet below the ground and the surface mark in a bowlder 12 by 18 by 24 inehes. The reference marks are copper bolts set in the eenter of triangular blazes on each of three stumps on the sides faeing the station, the first being 9.24 meters from the station in azimuth 104° 22′, the seeond 9.13 meters, in azimuth 165° 16′, and the third 7.90 meters, in azimuth 345° 34′. Two blazed trees are at the following distances and azimuths from the station: 18.24 meters, 152° 52′; and 26.44 meters, 257° 50′.

Huck (Lewis County, Wash., O. B. F., 1905).—On a high, bald summit, known loeally as Huekleberry Mountain, and about 8 miles northwest of the highest point of the Deschutes

[1] See p. 43.

Mountains in this region. The station is on a level place on the summit and about 60 feet north of a sharp rocky point of about the same height. The station is marked by a one-half inch drill hole 1 inch deep in the top of a bowlder 8 by 8 by 10 inches set flush with the surface of the ground. The reference marks, three in number, are similar drill holes in solid ledges along the west side of the ridge a little below its top, and at the following distances and azimuths from the station: 13.65 meters, 40°; 7.30 meters, 60°; and 5.60 meters, 136°.

Bel (Pierce County, Wash., O. B. F., 1905).—On a high rocky peak known as "Bel Jacket," about 10 or 12 miles a little south of west of Mount Tacoma, and about 9½ miles by road from Ashford. From Ashford there is a wagon road leading to Messler's place about 5 miles distant, then a trail in the direction of Bald Rock and Eagle Rock, which leads to a small lake from where the peak may be seen about one-half mile distant a little to the west of north. The station is marked according to note 3.[1] Three reference marks, described in note 4,[1] are at the following distances and azimuths from the station: 7.26 meters, 328° 46′; 5.24 meters, 16° 22′; and 5.94 meters, 188° 29′. A drill hole is 16.89 meters from the station in azimuth 15° 01′.

Hal (Lewis County, Wash., O. B. F., 1905).—On the highest point of the most western one of the high, bald summits of the Deschutes Mountains near the northern line of Lewis County and due south of Tacoma. From the north the mountain appears as a symmetrical cone and is best approached from Yelm, a town on the Northern Pacific Railway, via Peter Stone's ranch, which is about 14 miles southeast of Yelm and a short distance north of the station. The station is near the south point of the hilltop and marked according to note 3.[1] Three reference marks, described in note 4,[1] are located as follows: The first in a large bowlder, 10.55 meters from the station in azimuth 166° 24′, the second in a broad sloping ledge 4.81 meters distant in azimuth 333° 35′, and the third in about the highest point of rocks 2.71 meters distant in azimuth 13° 07′.

Rain (Thurston County, Wash., O. B. F., 1905).—About 10 meters northwest of the highest point of a prominent high hill about 4 miles south-southeast of the town of Rainier, about 1,200 feet above it, and just visible over the top of the timber from the town. It is probably in sec. 33, T. 16, R. 1 E., and it is about a mile west-northwest of the ranch on the top of the ridge owned by N. N. Bungard. The station is marked according to note 2,[1] the subsurface mark in a bowlder about 10 by 12 by 12 inches and 15 inches below the surface of the ground, and the surface mark in a bowlder 12 by 20 by 20 inches. Two reference marks, described in note 4,[1] are located as follows: One in a large bowlder at the highest part of the hill, 8.75 meters from the station in azimuth 8° 54′, and the other in a bowlder at some distance down the slope of the hill and 13.78 meters from the station in azimuth 218° 42′.

Hurst (Pierce County, Wash., O. B. F., 1905).—Near the north end and highest part of the timbered hill about 400 meters slightly south of west from the railroad station at Hillhurst, a town on the Northern Pacific Railway, and about one-half mile southwest of the store and post office. The hill is across the road south from the Cottage Grove farm, owned by Mr. Bucholtz. The station is marked at the surface with an old-type station mark, described on page 42, set in a concrete block 12 inches square and 18 inches deep, and underground by a one-half inch copper bolt 4 inches long set in the solid ground or native cement 3 feet beneath the surface. There are two reference marks, one of which is a copper bolt set in the only large rock in the neighborhood, 40.34 meters from the station in azimuth 252° 40′, and the other is a similar copper bolt in a bowlder 10 by 12 by 12 inches flush with the surface of the ground, with a smaller bowlder 8 by 10 by 10 inches directly below it, and is 13.52 meters from the station in azimuth 150° 41′.

Pen (Pierce County, Wash., O. B. F., 1905).—About one-half mile south of Graham, a station on the Tacoma Eastern Railroad, about one-half mile northwest of Mr. Hansen's house, and 75 or 100 meters to the westward of the highest part of a flat, partly cleared summit. The station is marked according to note 2.[1] Three reference marks, described in note 4,[1] are at the following distances and azimuths from the station: 18.93 meters, 242° 50′; 17.80 meters, 37° 58′; and 23.15 meters, 160° 53′.

[1] See p. 43.

Tacoma south base (Pierce County, Wash., O. B. F., 1905).—About 10 miles south of Tacoma and 2 miles south of Spanaway Lake, on land belonging to William Sekor, in the prolongation of Pacific Avenue of Tacoma. From the top of the hill in South Tacoma this street is nearly a straight line and Tacoma base line lies along it. The station is on the highest bench near the south side of Sekor's property and near the highest point of the bench, being about 10 feet west of a small but prominent knoll. It is 178.5 meters from the fence on the south side of the field and 154.8 meters from the fence on the west side. The station is marked underground by a cross in the head of a one-half inch copper bolt 3 inches long set in a block of concrete 2½ feet square and 6 inches thick 3 feet beneath the surface, and at the surface by an old-type station mark, described on page 42, set in the top of a concrete cube 2½ feet on an edge which has a 4-inch drain tile 2 feet long at the center with its top flush with the surface of the concrete. There are three reference marks, each consisting of a copper bolt set in a concrete block 18 inches square and 6 inches thick buried 3 feet below the surface, and of a similar bolt above it in a concrete block 18 inches square and 30 inches deep, its top 2 inches below the surface of the ground. They are at the following distances and azimuths from the station: 49.658 meters, 263° 50′; 38.938 meters, 347° 25′; and 61.153 meters, 173° 25′.

Tacoma north base (Pierce County, Wash., O. B. F., 1905).—On Fern Hill, 4 miles south of Tacoma and about one-fourth mile north of the crossing of Pacific Avenue and the Puyallup Electric Railway. It is on a prominent knoll just south of the house owned and occupied by H. A. Wilhelmi, 8.5 meters south of his south line and 19 meters east of the east line of Pacific Avenue. The subsurface mark at the station is a cross in the head of a one-half inch copper bolt 3 inches long set in a block of concrete 30 by 30 inches and 6 inches thick, 3 feet beneath the surface. The surface mark is an old-type station mark, described on page 42, set in a concrete cube 2½ feet on an edge which has a 4-inch drain tile 2 feet long at the center with its top flush with the surface of the concrete. There are three reference marks, each consisting of a one-eighth inch copper wire embedded in an underground block of concrete 14 by 14 inches and 6 inches thick set 3 feet below the surface, and of a surface mark consisting of a similar wire in a block 14 by 14 by 30 inches set with the top flush with the surface of the ground. They are located as follows: The first, just north of Dr. Rynning's north fence and 4 feet east of the east line of Pacific Avenue, 92.325 meters from the station in azimuth 10° 19′; the second, south of the back part of Wilhelmi's house and just south of his south fence, 47.757 meters from the station in azimuth 259° 51′; and the third just south of Wilhelmi's south fence and 2 feet east of the east line of Pacific Avenue, 19.672 meters from the station in azimuth 117° 04′.

Burn (Pierce County, Wash., O. B. F., 1905).—On a prominent ridge 2 or 3 miles southwest of the central part of the city of Tacoma, west of that part of the valley which is traversed by the Northern Pacific Railway in an east-and-west direction and almost in line with the east-and-west portion of the track, about three-fourths of a mile from its western end. It is on a summit about one-half mile west of a prominent schoolhouse, about 300 meters southeast of a house, and about 30 meters north of a private road leading from the house to the schoolhouse. The station is marked according to note 2,[1] with the subsurface bowlder about 2 feet below the surface. Three reference marks, described in note 4,[1] are located as follows: The first near a trail along the ridge and 23.53 meters from the station, in azimuth 160° 44′; the second on the north edge of the road 25.13 meters distant, in azimuth 320° 00′; and the third near the beginning of a slope 25.47 meters distant, in azimuth 85° 34′.

Kin (Pierce County, Wash., O. B. F., 1905).—On the top of a prominent hill in the southeastern part of Tacoma, just south of McKinley Park, in the block between Thirty-second Street and Wright Avenue and K and L Streets and very nearly halfway between Thirty-second Street and Wright Avenue. It is directly in line with the gable ends of the N. P. B. A. Hospital, a large brick building a couple of hundred yards to the westward of the station. The station is marked according to note 2.[1] Two reference marks, described in note 4,[1] are at the following distances and azimuths from the station: 24.55 meters, 215° 48′; and 18.47 meters, 294° 50′.

[1] See p. 43.

Wash (Pierce County, Wash., O. B. F., 1905).—In the northwestern part of Tacoma, near the middle of Twenty-fifth Street and about 5 yards east of the east line of Washington Street projected across Twenty-fifth Street at their intersection. The station is marked by an old-type station mark, described on page 42, in a bowlder 18 by 24 by 30 inches, which is buried with its top about 5 inches below the surface of the ground. Two reference marks, each consisting of a punch mark in the head of a copper slug in a stone 2 feet below the surface and of a similar slug in a stone directly above the lower mark and about 3 inches beneath the surface, are located as follows: One at the northeast intersection of Twenty-fifth and Washington Streets, about 1½ feet east of the east line of Washington Street, 1 foot north of the north line of Twenty-fifth Street and 9.634 meters from the station, in azimuth 153° 20′; and the other at the southeast intersection of the same streets, about 3 feet from Washington Street, 1 foot south of the south line of Twenty-fifth Street and 17.713 meters from the station, in azimuth 12° 22′.

Bos (Pierce County, Wash., O. B. F., 1905).—In the flat about 2 miles east of Tacoma and one-third of a mile south of the trestle leading from the city across the marsh to the mills on the east side of the valley. It is about 75 meters northeast of a small white house at the north end of the strip of fast land which extends farthest into the marsh and on a very slight elevation, clear of trees and buildings, on the edge of a slough. The station is marked according to note 2,[1] the lower mark in a small bowlder 15 inches below the surface and the upper mark in a bowlder about 10 inches in diameter projecting 3 inches above the surface of the ground. There are no reference marks, but a broken-topped fir tree is about 60 meters from the station, in azimuth 331° 44′, and the west corner of the small white house is 77.72 meters distant, in azimuth 13° 54′.

Gull (King County, Wash., J. J. G., 1891; 1905).—On Commencement Bay, north of Tacoma, and about 1 mile southeast from Brown Point Lighthouse, on the bold bluff about 125 feet high, which is conspicuous on approaching the point from Tacoma. The station is about 15 feet from the edge of the bluff and in range with the tower of the Lowell School in Tacoma and the left tangent of the tall, dark, cylindrical building with a dome roof, which belongs to the Tacoma Lumber Co.'s mill, and bears about southwest from the station. The station is marked by a bottle buried 2½ feet below the surface and by a nail in a pine stub at the surface of the ground.

Dron (King County, Wash., O. B. F., 1905).—On Commencement Bay, about one-half mile southeast of Brown Point Lighthouse and about one-half mile west of station *Gull*. It is on the highest part of a bluff point about 60 feet above the water and 20 or 25 feet inland from the edge of the bluff, in a thicket of madrona trees, some of which were felled to clear the line to station *Neill*. The station is marked according to note 2.[1] Two reference marks, described in note 4,[1] are at the following distances and azimuths from the station: 4.42 meters, 175° 08′; and 5.01 meters 308° 03′.

Smelt (Pierce County, Wash., O. B. F., 1905).—On a ridge in the extreme northwestern part of Tacoma just south of Point Defiance Park. To reach the station follow the electric line, which runs to the smelter, to a point about 300 yards beyond where the cars make the last turn at Highland Park, and there take the road which leads toward the west, following it until the top of the ridge is reached. From there keep along the ridge toward the north until the Brown Point lighthouse and the left tangent to the second smelter chimney to the north of the 300-foot smelter stack are in range, then follow this range to within 5 or 10 yards of the edge of the plateau. The station is not far from the west end of the main ridge, considerably below the highest point, and at about the same elevation as a small knoll some 300 feet to the west. The station is marked according to note 2,[1] except that the subsurface mark is a one-half inch drill hole in a stone 18 inches below the surface. The surface mark is in a bowlder 10 by 18 by 18 inches set flush with the surface of the ground. One reference mark consists of punch holes in the heads of copper slugs set in each of two stones, one 15 inches underground and the other at

[1] See p. 43.

the surface, 28.55 meters from the station in azimuth 27° 38′. The other reference mark is a copper slug set in a stone in place 53.16 meters from the station in azimuth 236° 33′.

Neill 2 (Pierce County, Wash., O. B. F., 1905).—On Neill Point at the southeast end of Vashon Island, about 6 or 8 feet above high-water mark and 15 feet inland from it. The station is marked only by a tack in the top of a pine stub.

Tacoma astronomic station (Pierce County, Wash., J. F. P., 1892; 1905).—A stone pier near the north end of Wrights Park, Tacoma. A brick pier 17 inches square and 5½ feet long, used for latitude observations in 1894, is 12 feet 3 inches due east of the station.

SUPPLEMENTARY POINTS.

Corning tower (Tehama County, Cal., O. B. F., 1904).—The tower at the south end of the Maywood Colonization Building, a wood and plaster structure, just across the street from the Maywood Hotel and southwest from the railroad station.

Corning astronomic station (Tehama County, Cal., W. H. B., 1908).—On the vacant lot just west of the Maywood Colonization Building at Corning. (See Corning tower, above.) The station is not marked but the following distances and azimuths to different parts of the Maywood Colonization Building were measured. Tower, 23.40 meters, 247° 24′.2; northwest corner of the porch-like part of the building known as the Arcade, 31.40 meters, 207° 55′.2; and southwest corner of the same Arcade, 16.64 meters, 242° 17′.8.

Redding courthouse (Shasta County, Cal., O. B. F., 1904; 1908).—The center of the top of the dome of the courthouse upon which stands the statue of justice. The statue is eccentric to the center of the dome by about 1½ feet. A triangle with a small hole at the center is cut in the floor of the dome directly below the center of the dome and may be used as the station.

Redding astronomic station (Shasta County, Cal., O. B. F., 1904; 1908).—On a prominent hill about three-fourths of a mile south by west from the railroad station at Redding. To reach the station follow the railroad track south to milepost 259, which is marked at present by a board nailed to a telegraph pole, where will be found a United States Geological Survey bench mark, a metal tube with a brass top, and from here the station is west about one-fourth of a mile. The station is on the brow of a hill somewhat toward the south edge and not quite at the highest point. A live oak about 6 inches in diameter is on the edge of the hill just north of the line to the Geological Survey bench mark and a leaning pine tree about a quarter of a mile distant is in line with the Redding courthouse. The station is marked according to note 1,[1] in the top of a large bowlder projecting 4 inches above the ground. Two reference marks, described in note 4,[1] are at the following distances and azimuths from the station: 20.22 meters, 115° 49′; and 9.99 meters, 188° 17′.

Redding south base (Shasta County, Cal., W. H. B., 1908).—About 15 feet east of the railroad track at Redding and opposite a large steel oil tank. The station is marked only by a nail in the top of a wooden stub and by the three instrument stubs.

Redding north base (Shasta County, Cal., W. H. B., 1908).—Near the northwest corner of the cemetery south of the railroad station at Redding and about 15 feet east of the track. The station is marked only by a nail in a wooden stub and by the three instrument stubs around it.

Hill (Shasta County, Cal., W. H. B., 1908).—On the east brow of a ridge just north of the ridge on which *Redding astronomic station* is located (see above), and almost on the line between that station and the courthouse at Redding. The station is marked only by a wooden stub and the three instrument stubs surrounding it.

Central Point astronomic station (Jackson County, Oreg., O. B. F., 1904; 1908).—About 2 miles north of Central Point, near the intersection of the Southern Pacific Railway and the county road and in the northwest corner of the field which is just east of the county road and south of the private road leading to the house occupied by George Mims. The station is about 30 meters from the railroad. (See *Central Point latitude station*, below). The underground mark at the station is a three-fourths inch drill hole in the top of a triangular granite

[1] See p. 43.

rock, set in cement 15 inches below the surface of the ground. The surface mark is an old-type station mark, described on page 42, set in the top of a granite rock which projects 2 inches above the surface and which is embedded in a mass of concrete 30 inches square and 12 inches deep. The reference mark, a United States Geological Survey bench mark, is at the intersection of the railroad and the county road, just east of the rail on the east side of the road and 28.15 meters from the station in azimuth 31° 55′.

Central Point latitude station (Jackson County, Oreg., W. H. B., 1908).—Near *Central Point astronomic station* (see above) and marked only by a wooden pier. The following distances and azimuths were measured: Astronomic station, 4.77 meters, 116° 41′; United States Geological Survey bench mark (reference mark of astronomic station), 28.82 meters, 41° 18′. The north and west fences of the field are, respectively, 6.18 meters and 15.55 meters from the station.

Rose (Douglas County, Oreg., O. B. F., 1904).—On the highest point of the highest bald summit of a ridge about 1½ miles north of Roseburg. The station is marked according to note 2,[1] the underground mark in a mass of concrete 1 foot below the surface and the surface mark in a bowlder 9 by 14 by 18 inches flush with the surface of the ground. Two reference marks, described in note 4,[1] are at the following distances and azimuths from the station: 16.71 meters, 12° 24′; and 7.49 meters, 125° 23′.

Burg (Douglas County, Oreg., O. B. F., 1904).—On a high, bald summit about 3 miles southeast of Roseburg. As seen from the iron bridge over the river just west of the railroad station, it is the highest and most distant peak visible up a small valley. The station is marked according to note 2,[1] the underground mark in a mass of concrete 13 inches below the surface, and the surface mark in a bowlder 10 by 12 by 14 inches set flush with the surface of the ground. The reference mark, described in note 4,[1] is in a bowlder just over the edge of the hill, 10.24 meters from the station in azimuth 112° 45′.

Roseburg latitude station (Douglas County, Oreg., O. B. F., 1904).—On the point of a spur across the river from the town of Roseburg, about 100 feet west from the end of the bridge and 60 feet above it. The station is marked according to note 1,[1] set in a ledge of rock. Two reference marks, described in note 4,[1] are located as follows: One in a prominent ledge 18.18 meters from the station in azimuth 30° 17′, and the other in the side of a ledge flush with the ground, 32.30 meters from the station in azimuth 109° 05′.

Springfield Methodist Church (Lane County, Oreg., W. H. B., 1908).—The lower and less prominent of the two churches at Springfield.

Springfield Christian Church (Lane County, Oreg., W. H. B., 1908).—The taller and more prominent of the two churches at Springfield.

Deady Hall, west tower (Lane County, Oreg., W. H. B., 1908).—Deady Hall is one of the two larger buildings of the University of Oregon at Eugene and has large square towers at both the east and west ends.

Geary School spire, Eugene (Lane County, Oreg., W. H. B., 1908).—The Geary School is the public school located at West Fourth and Madison Streets, Eugene.

United Brethren Church spire, Eugene (Lane County, Oreg., W. H. B., 1908).—At East Eleventh and Ferry Streets, Eugene.

Patterson School spire, Eugene (Lane County, Oreg., W. H. B., 1908).—The public school located one block west of the southwest corner of the campus of the University of Oregon, at Eugene.

Baptist Church spire, Eugene (Lane County, Oreg., W. H. B., 1908).—At East Eighth and Pearl Streets, Eugene.

W. O. W. Hall spire, Eugene (Lane County, Oreg., W. H. B., 1908).—The old Episcopal Church located at West Eighth and Lincoln Streets, Eugene, which is now being used as a hall by the Woodmen of the World.

Courthouse flagpole (Lane County, Oreg., W. H. B., 1908).—At East Eighth and Oak Streets, Eugene.

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[1] See p. 43.

Methodist Church spire (Lane County, Oreg., W. H. B., 1908).—The Humphrey Memorial M. E. Church located at West Tenth and Willamette Streets, Eugene.

Seavies (U. S. G. S.) (Lane County, Oreg., O. B. F., 1904).—This station is identical with the United States Geological Survey station of the same name. It is on the most southern of the high hills, about 6 miles northeast of Eugene and about 30 or 40 feet southwest of and slightly lower than the highest part of the hill. The station is marked by a square stone 4 by 4 by 24 inches with its top a little below the surface. The old Geological Survey signal was still standing in 1904, anchored in place by rocks, and was not disturbed.

Monument, General Land Survey (Multnomah County, Oreg., O. B. F., 1903).—The initial intersection of the First Standard Parallel and the Willamette Meridian, a short distance southeast of *Barnes*. (See p. 49.) The station is in a fence corner and is marked by a stone post projecting 1½ feet above the ground.

River (Multnomah County, Oreg., O. B. F., 1903).—Near the junction of the two suburbs of Portland known as Arbor Lodge and Peninsula, on the east bank of the Willamette River about a mile east of Columbia University. It is on a slight elevation, the highest in the vicinity, and in the fence line on the north side of the boulevard along the river bank. It was placed as far east as possible and still keep the Oregonian Building in view. The station is marked by crosses cut in the tops of two bowlders, one placed near the surface of the ground and the other directly beneath at a depth of 1.7 feet, each stone bearing the letters "U. S. C. S." cut in the top.

Oregonian (Multnomah County, Oreg., O. B. F., 1903).—The tall iron pole at the southeast corner of the tower of the Oregonian Building at the northwest corner of Sixth and Adler Streets, Portland.

Portland longitude station (Multnomah County, Oreg., C. H. S., 1887; 1905).—This station has been destroyed.

Portland latitude station (Multnomah County, Oreg., C. H. S., 1887; 1905).—This station has been destroyed.

Rocky Butte (Multnomah County, Oreg., C. R., 1889; 1903).—On the north side of the highest part of the brush-covered summit of the butte, about 2 miles northeast of Montavilla. The station is marked by a hole drilled in a large round-topped bowlder.

Harney (Clarke County, Wash., C. R., 1881; 1903).—On the north bank of the Columbia River, about 1½ miles above the United States wharf at Vancouver, on the sloping bare bluff immediately above the road leading from Vancouver up the river. It is almost in front of the "Harney House," on land formerly owned by Gen. Harney, and about 80 meters east of the fence inclosing the race track. The underground mark consists of a glass bottle placed 3 feet below the surface, with the neck up, the center of the neck marking the station, and three other bottles placed on their sides at a depth of about 1 foot and at distances of about 6 feet from the center, with the necks of the bottles pointing toward the center. The surface mark is a small drill hole 2 inches deep in a basaltic bowlder, weighing about 350 pounds, placed with its top flush with the surface of the ground. The following bearings to the right of magnetic north were read at the station: East chimney of Harney House, 27° 05′; triangle on tree 74° 28′; white house on south side of river, 172° 55′; ventilator on barn, 220° 06′; and corner of race track fence, 276° 47′.

Balch (Multnomah County, Oreg., C. R., 1881; 1906).—This station was occupied for azimuth in 1886. It is immediately northwest of the city limits of Portland, about a mile south of the Willamette River, on the first small level bench of the spur making out from the ridge west of the Cornell road, and about 255 feet above the road. The station is marked underground by a broken-necked bottle placed neck up 2 feet below the surface, and by a cross in the top of a copper bolt set in concrete 6 inches above the bottle, and at the surface by a cross on an old-type station mark described on page 42, set in concrete, which is inscribed with the letters "C. & G. S." The reference marks are the remains of two brick piers built in line to the west of the station, with their foundation about 20 inches below the surface, the nearest edge of the first pier being about 1 meter west of the station.

Dash (King County, Wash., G. D., 1857; 1905).—On the sand spit called Dash Point, about 1 mile northeast of Brown Point Lighthouse and 10 or 12 feet back from the high-water mark. The station is inclosed within a wall of old timbers to protect it from the washing of the waves, and is marked by a one-half inch drill hole 2 inches deep in a stone buried a foot beneath the surface. Two reference marks, probably drill holes in bowlders, are at the following distances and azimuths from the station: 18.05 meters, 284° 34′; and 37.32 meters, 352° 21′. A blazed fir tree is about 60 meters distant in azimuth 324° 41′.

Piner 2 (King County, Wash., O. B. F., 1905).—On the southeast point of Maury Island, about 25 feet above high tide and 30 or 40 feet inland from high-water mark. A group of four piles is 30 or 40 meters east of the station, and a large rock, the largest in the vicinity, is in the water 50 or 60 meters south and a little west from the station. The station is marked by a three-fourths inch drill hole in a large stone set flush with the surface, and underground by a similar drill hole in a stone 2 feet below the surface of the ground. Two reference marks, each consisting of surface and subsurface stones, are at the following distances and azimuths from the station: 4.61 meters, 86° 55′; and 4.65 meters, 167° 45′.

Robinson 2 (King County, Wash., J. S. L., 1867; 1905).—On Robinson Point, on Maury Island, about 300 meters southwest of the scaffold light, on a bluff about 20 feet above high tide and 30 feet inland from high-water mark. The station is 95 meters southwest of the light keeper's dwelling, 42 meters southwest from the southeast corner of the light keeper's shed or barn, and about 2 meters west of the fence which extends southwest from the corner of the shed. A large madrona tree at the top of the bluff is 15 or 20 meters southwest of the station. The station is marked underground by a one-half inch drill hole in a stone buried 1 foot deep and at the surface by a similar hole in a stone, directly above the lower mark, set with its top flush with the surface of the ground. One reference mark is a one-half inch drill hole in a solid stone which is in line with the fence running southwest from the shed, and is 2.93 meters from the station in azimuth 26° 25′. The other reference mark consists of surface and subsurface stones, the lower one 1½ feet beneath the surface, and is 10.62 meters from the station in azimuth 185° 06′.

COMPUTATION, ADJUSTMENT, AND ACCURACY OF THE ELEVATIONS.

The zenith distances directly observed at each station were first computed. These zenith distances were corrected for height of the object observed and of instrument so as to refer them all to the ground at each station or to the station marks.

The difference of elevation of each pair of stations in the main scheme was then computed from the observations over the line joining them by the formula

$$h_2 - h_1 = s \tan \tfrac{1}{2} (\zeta_2 - \zeta_1) \left[1 + \frac{h_2 + h_1}{2\rho} + \frac{s^2}{12\rho^2} \right]$$

in which h_2 and h_1 are elevations of the stations, ζ_2 and ζ_1 are the measured zenith distances as corrected for height of instrument and of object observed, s is the horizontal distance between the stations, and ρ is the radius of curvature.

As there are always two or more lines to each new station, many rigid conditions exist between the observed difference of elevation, even if the connections with the precise leveling were ignored, and the least square adjustment furnishes the readiest accurate means of deriving the required elevations.

The elevations of the primary scheme throughout the arc from the stations of the Thirty-ninth Parallel triangulation to Puget Sound were adjusted in three sets of equations.

The first adjustment involved all stations of the primary scheme from the Thirty-ninth Parallel to the Willamette base.

The second adjustment fixed the elevations of the primary stations connecting the Tacoma base with the Puget Sound triangulation.

The third adjustment fixed the elevations of the primary stations between the Willamette base net and the Tacoma base as well as the secondary stations connecting these with the Columbia River.

In the first adjustment the elevations of stations Redding astronomic, Gazelle astronomic, Central Point astronomic, and Roseburg latitude were held fixed at 202.16, 848.28, 369.92, and 165.24 meters, respectively. These elevations were determined directly from the leveling of the United States Geological Survey. The precise leveling over the base and over a side line 1 kilometer in length connected the terminal marks of the Willamette base with the bench mark 4 miles north of Irving, also established in 1903 by the United States Geological Survey. The elevation published for this bench mark [1] was increased by 0.286 foot (0.087 meter) and the elevations 101.36 and 116.59 meters adopted for the Willamette north base and south base, respectively.

The elevations of Mount Helena and Snow Mountain West were held fixed by the adjustment published in Special Publication No. 4, page 279, as 1322.08 and 2145.66 meters, respectively. The zenith distances measured at these stations in 1876 and 1892 were used to fix the elevations of Snow Mountain East and Marysville Butte. They were first changed by eliminating all observations made near sunrise and sunset, as these have been proved unreliable. They were then treated as reciprocal observations in connection with the zenith distances measured in 1904 at the latter stations. The elevation of Snow Mountain East was held fixed at 2,150.56 meters as determined directly from Snow Mountain West, a line only 923 meters in length.

The elevations of the 26 remaining stations connected by the observations are unknowns, to be determined by least squares from the 82 observed differences of elevation indicated below.

In the following tabulation there are shown the observed differences of elevation treated in the first adjustment, together with their adjusted values. The weight p assigned to each observed difference of elevation is inversely proportional to the square of the length s of the line between stations in meters and was conveniently computed by the formula $\log p = 10 - 2 \log s$. The observed difference of elevation is given the sign of the elevation of the second station named minus the elevation of the first. The quantity contained in the last column but one is the correction to be added to an observed difference of elevation to obtain the adjusted difference of elevation.

Adjustment of elevations—Thirty-ninth Parallel to Willamette base.

Station 1	Station 2	Weight p	Observed difference of elevations h_2-h_1	Adjusted difference of elevations h_2-h_1	Adjusted minus observed v	pv^2
			Meters	*Meters*	*Meters*	
Mount Helena	Marysville Butte	1.18	− 679.36	− 684.06	− 4.70	26.1
Snow Mountain east	Marysville Butte	1.46	−1509.66	−1512.54	− 2.88	12.1
Marysville Butte	Kent	0.75	+1400.46	+1394.88	− 5.58	23.3
Snow Mountain east	Kent	2.38	− 117.49	− 117.66	− 0.17	0.1
Snow Mountain east	Lyons	0.51	− 113.31	− 119.17	− 5.86	17.5
Marysville Butte	Lyons	0.67	+1401.75	+1393.37	− 8.38	47.0
Kent	Lyons	0.99	− 1.46	− 1.51	− 0.05	0.0
Kent	Bally	1.98	− 140.12	− 140.49	− 0.37	0.3
Lyons	Bally	1.18	− 138.32	− 139.03	− 0.71	0.6
Redding	Bally	20.75	+1690.41	+1690.20	− 0.21	0.9
Kent	Round	0.77	− 984.69	− 989.49	− 4.80	17.7
Lyons	Round	2.59	− 984.99	− 988.00	− 3.01	23.5
Bally	Round	2.55	− 849.51	− 848.97	+ 0.54	0.7
Bally	Spur	1.10	+ 878.12	+ 874.52	− 3.60	14.3
Round	Spur	2.00	+1728.70	+1723.49	− 5.21	54.3
Bally	Boliver	1.84	+ 561.09	+ 559.17	− 1.92	6.8
Spur	Boliver	4.48	− 314.61	− 315.35	− 0.74	2.5
Round	Mears	3.37	+1130.59	+1130.67	+ 0.08	0.0
Spur	Mears	8.05	− 593.20	− 592.82	+ 0.38	1.0

[1] See p. 134, Report for 1907.

Adjustment of elevations—Thirty-ninth Parallel to Willamette base—Continued.

Station 1	Station 2	Weight p	Observed difference of elevations h_2-h_1	Adjusted difference of elevations h_2-h_1	Adjusted minus observed v	pv^2
			Meters	*Meters*	*Meters*	
Boliver	Mears	10.00	− 277.13	− 277.47	− 0.34	1.2
Spur	Sterling	1.34	− 529.07	− 527.60	+ 1.47	2.9
Boliver	Sterling	1.40	− 214.04	− 212.25	+ 1.79	4.5
Spur	Soda	1.70	− 910.22	− 909.51	+ 0.71	0.8
Boliver	Soda	1.16	− 589.01	− 594.16	− 5.15	30.7
Sterling	Soda	8.55	− 382.03	− 381.91	+ 0.12	0.1
Spur	Gazelle	14.35	−1917.40	−1918.60	− 1.20	20.6
Soda	Gazelle	2.79	−1008.31	−1009.09	− 0.78	1.7
Sterling	Onion	1.56	− 643.06	− 642.14	+ 0.92	1.3
Soda	Onion	1.15	− 265.88	− 260.23	+ 5.65	36.7
Sterling	Rust	1.55	− 349.39	− 348.11	− 1.28	2.5
Soda	Rust	2.56	+ 34.39	+ 33.80	− 0.59	0.9
Onion	Rust	1.89	+ 296.04	+ 294.03	− 2.01	7.6
Soda	Central Point astronomic station	3.55	−1485.41	−1487.45	− 2.04	14.8
Onion	White	3.98	− 378.66	− 374.42	+ 4.24	71.6
Rust	White	1.59	− 666.36	− 668.45	− 2.09	6.9
Onion	Black	1.51	+ 280.62	+ 276.97	− 3.65	20.1
White	Black	4.54	+ 650.04	+ 651.39	+ 1.35	8.3
White	Scott	12.71	+ 70.91	+ 71.91	+ 1.00	12.7
Black	Scott	3.40	− 579.72	− 579.48	+ 0.24	2.0
White	Burg	18.45	− 614.95	− 614.02	+ 0.93	16.0
Scott	Burg	10.26	− 685.60	− 685.93	− 0.33	1.1
Scott	Rose	14.96	− 842.96	− 841.32	+ 1.64	40.2
Burg	Rose	147.60	− 155.37	− 155.39	− 0.02	0.0
White	Rose	14.32	− 770.06	− 769.41	+ 0.65	6.0
Burg	Roseburg latitude station	258.80	− 443.53	− 443.46	+ 0.07	1.3
Rose	Roseburg latitude station	704.70	− 288.12	− 288.07	+ 0.05	1.8
White	Fairview	2.74	+ 585.20	+ 583.54	− 1.66	7.6
Black	Fairview	4.05	− 67.79	− 67.85	− 0.06	0.2
Scott	Fairview	5.98	+ 511.90	+ 511.63	− 0.27	0.4
White	Yellow	3.21	− 467.84	− 476.38	− 8.54	234.0
Scott	Yellow	8.89	− 547.63	− 548.29	− 0.66	3.9
Fairview	Roman	1.12	− 929.52	− 933.98	− 4.46	22.3
Yellow	Roman	4.21	+ 124.23	+ 125.94	+ 1.71	12.3
Fairview	Spencer	3.11	−1179.64	−1180.06	− 0.42	0.5
Yellow	Spencer	3.37	− 108.13	− 120.14	−12.01	486.0
Roman	Spencer	3.67	− 245.30	− 246.08	− 0.78	2.2
Roman	Mary	2.20	+ 376.11	+ 376.57	+ 0.46	0.5
Spencer	Mary	2.13	+ 620.63	+ 622.65	+ 2.02	8.7
Roman	Peterson	1.22	− 434.71	− 435.05	− 0.34	0.1
Spencer	Peterson	2.83	− 188.71	− 188.97	− 0.26	0.2
Mary	Peterson	4.64	− 812.75	− 811.62	+ 1.13	5.9
Roman	Twin	1.80	− 484.93	− 482.47	+ 2.46	10.9
Spencer	Twin	6.68	− 235.93	− 236.39	− 0.46	1.4
Mary	Twin	4.34	− 859.07	− 859.04	+ 0.03	0.0
Peterson	Twin	23.17	− 47.44	− 47.42	+ 0.02	0.0
Spencer	Ridge	7.38	− 265.01	− 265.18	− 0.17	0.0
Peterson	Ridge	6.35	− 75.79	− 76.21	− 0.42	1.1
Twin	Ridge	13.68	− 28.69	− 28.79	− 0.10	0.1
Spencer	Rauch	27.61	− 423.18	− 423.96	− 0.78	16.8
Peterson	Rauch	2.59	− 235.91	− 234.99	+ 0.92	2.2
Twin	Rauch	5.35	− 188.00	− 187.57	+ 0.43	1.0
Ridge	Rauch	12.65	− 159.32	− 158.78	+ 0.54	3.7
Spencer	Willamette north base	15.81	− 524.13	− 524.84	− 0.71	5.2
Twin	Willamette north base	20.32	− 288.04	− 288.45	− 0.41	3.5
Ridge	Willamette north base	62.66	− 259.46	− 259.66	− 0.20	2.5
Rauch	Willamette north base	20.61	− 99.83	− 100.88	− 1.05	22.7
Spencer	Willamette south base	68.87	− 509.40	− 509.61	− 0.21	3.0
Peterson	Willamette south base	3.67	− 321.72	− 320.64	+ 1.08	4.3
Twin	Willamette south base	9.68	− 274.19	− 273.22	+ 0.97	9.1
Ridge	Willamette south base	16.14	− 244.48	− 244.43	+ 0.05	0.0
Rauch	Willamette south base	61.52	− 85.84	− 85.65	+ 0.19	2.2

The probable error of an observation of weight unity derived from the preceding adjustment is ±1.08 meters. In other words, the reciprocal observations over a line 31.7 kilometers (19¾ miles) long,[1] this being the length of line corresponding to unit weight, determined the difference of elevation of two points with such a degree of accuracy that it is an even chance whether the error is greater or less than 1.08 meters.

This probable error is unfair because of the fact that observations at the stations Roman and Spencer in June and July, 1903, were used in connection with those at Yellow and Fairview in October, 1904. The necessary assumption that the refraction is the same in the reciprocal observations was undoubtedly wrong in this case. The reason the four lines were retained in the adjustment was to connect the elevations of the two seasons. A rejection of the two lines, Yellow-Spencer and Yellow-White, reduces the probable error of an observation of unit weight from ±1.08 to ±0.77 meter. The latter is believed to represent more faithfully the value of the vertical angle results in this work.

The probable errors for lines of other than unit length were assumed to be proportional to their lengths.

The probable errors of the elevations of the six stations fixed by the spirit leveling done by the United States Geological Survey are doubtless well within ±0.3 meter. The probable error approaches this value for stations adjacent to those fixed by the leveling and is greatest for the most remote stations. The probable error of the elevation of Mount Helena was computed as ±0.62 meter and of Snow Mountain West as ±1.14 meters.[2] Snow Mountain West may be considered as the least accurately determined and this probable error, derived from the old work, ±1.14 meters, may be assumed to be as large as for any station in the entire arc.

The new elevation here computed for Marysville Butte, 638.0 meters, very properly supersedes that published on page 312 of Special Publication No. 4, which was determined solely from nonreciprocal observations from which the early morning and late evening observations were not eliminated.

The elevations of the stations of the main scheme from the Tacoma base to the connection with the Puget Sound triangulation were obtained from the second adjustment as shown in the tabulation below. The elevation of Tacoma City Hall, a bench mark of the United States Geological Survey, was held fixed at 33.518 meters, a published elevation derived from tidal observations by this Survey. In addition to this the observed difference of elevation, −1.93 meters, between Tacoma north base and south base was superseded by the difference of elevation, −2.13 meters, from the precise levels run over the base line by the party measuring the base.

There is, then, in this section one fixed elevation and one fixed difference of elevation. The elevations of the 13 remaining stations connected by the observations are the unknowns to be determined by least squares from the 34 differences of elevation indicated in the following tabulation. They are shown in the same form used for the first adjustment, except that the weight p assigned to each difference of elevation was computed by the formula $\log p = 9 - 2 \log s$.

[1] This is the usual unit weight. A weight ten times as large was used in the above table.

[2] See p. 279, U. S. Coast and Geodetic Survey Special Publication No. 4.

Adjustment of elevations.—Puget Sound to Tacoma base.

Station 1	Station 2	Weight p	Observed difference of elevations h_2-h_1	Adjusted difference of elevations h_2-h_1	Adjusted minus observed v	pv^2
			Meters	*Meters*	*Meters*	
Tacoma City Hall	Kin	99	+ 69.00	+ 68.946	−0.054	0.287
Tacoma City Hall	Bos	54	− 30.96	− 30.925	+0.035	0.065
Kin	Bos	53	− 99.83	− 99.871	−0.041	0.090
Kin	Gull	19	− 50.87	− 50.789	+0.081	0.125
Bos	Gull	39	+ 49.14	+ 49.082	−0.058	0.133
Tacoma City Hall	Gull	50	+ 18.09	+ 18.157	+0.067	0.225
Tacoma City Hall	Dron	45	− 5.93	− 5.928	+0.002	0.000
Kin	Dron	17	− 74.95	− 74.874	+0.076	0.099
Bos	Dron	30	+ 24.94	+ 24.997	+0.057	0.096
Kin	Wash	23	+ 13.94	+ 13.814	−0.126	0.366
Bos	Wash	17	+113.67	+113.685	+0.015	0.003
Gull	Wash	40	+ 64.57	+ 64.603	+0.033	0.044
Dron	Wash	46	+ 88.52	+ 88.688	+0.168	1.297
Wash	Smelt	58	− 20.03	− 20.140	−0.110	0.702
Dron	Smelt	25	+ 68.50	+ 68.548	+0.048	0.058
Dron	Neill 2	37	− 23.41	− 23.567	−0.157	0.910
Wash	Neill 2	21	−112.11	−112.255	−0.145	0.441
Smelt	Neill 2	45	− 92.00	− 92.115	−0.115	0.594
Wash	Piner 2	14	−104.47	−104.039	+0.431	2.601
Wash	Dash	21	−114.21	−113.894	+0.316	2.098
Neill 2	Dash	41	− 1.33	− 1.639	−0.309	3.916
Piner 2	Dash	92	− 9.92	− 9.855	+0.065	0.386
Wash	Burn	49	+ 5.81	+ 5.860	+0.050	0.122
Kin	Burn	28	+ 19.74	+ 19.674	−0.066	0.123
Tacoma north base	Kin	33	− 22.27	− 22.231	+0.039	0.036
Wash	Tacoma north base	10	+ 8.35	+ 8.417	+0.067	0.045
Burn	Tacoma north base	21	+ 2.62	+ 2.557	−0.063	0.084
Gull	Tacoma astronomic station	62	+ 43.09	+ 43.112	+0.022	0.031
Neill 2	Tacoma astronomic station	14	+ 90.86	+ 90.764	−0.096	0.129
Burn	Tacoma south base	3.2	+ 0.56	+ 0.427	−0.133	0.057
Tacoma south base	Hurst	28	+ 6.66	+ 6.635	−0.025	0.017
Tacoma north base	Hurst	6.1	+ 4.77	+ 4.505	−0.265	0.428
Burn	Hurst	3.7	+ 6.43	+ 7.062	+0.632	1.478
Tacoma north base	Tacoma south base	6.9	− 1.93	− 2.13	−0.200	0.276

The probable error of an observation of weight unity derived from the preceding adjustment is ±0.61 meter. In other words, the reciprocal observations over a line 31.7 kilometers (19⅔ miles) long, this being the length of the line corresponding to unit weight, determined the difference of elevation of two points with such a degree of accuracy that it is an even chance whether the error is greater or less than 0.61 meter. The probable errors for lines of other lengths were assumed to be proportional to their lengths.

The probable error of the elevation of the station fixed by connection with the mean tide at Tacoma may be safely assumed at ±0.15 meter. The probable error approaches this value for stations adjacent to this station and is greatest for the most remote stations. The ends of the Tacoma base, connected as they are by precise levels, are the most remote and the probable error was computed for the base as a limiting value and was found to be ±0.09 meter from the vertical angle measures alone. When combined with the probable error of the fixed elevation it becomes ±0.17 meter.

In the third adjustment the elevations of the stations Mary and Peterson were held fixed as determined by the first adjustment, as 1248.82 and 437.22 meters, respectively. Similarly, the elevations of Tacoma north base, Tacoma south base, and Hurst were known from the second adjustment and their fixed elevations are 124.70, 122.57, and 129.20 meters, respectively. The secondary station Oregonian was fixed in elevation from a bench mark of the United States Geological Survey in Portland, Oreg. The elevation of top of tower is 69.22 meters.

The elevations of the 18 remaining stations connected by the observations are unknowns to be determined by least squares from the 52 observed differences of elevation indicated below. In this tabulation the observed differences of elevation are treated as in the first adjustment.

Adjustment of elevations— Willamette base net to Tacoma base.

Station 1	Station 2	Weight p	Observed difference of elevations h_2-h_1	Adjusted difference of elevations h_2-h_1	Adjusted minus observed v.	pv^2
			Meters	*Meters*	*Meters*	
Mary	Yam	2.05	− 896.20	− 894.41	+1.79	6.6
Peterson	Yam	2.53	− 82.62	− 82.81	−0.19	0.1
Mary	Hult	1.43	− 866.86	− 865.54	+1.32	2.5
Peterson	Hult	3.40	− 52.48	− 53.94	−1.46	7.2
Yam	Hult	7.87	+ 29.00	+ 28.87	−0.13	0.1
Yam	Barnes	2.77	+ 27.45	+ 29.10	+1.65	7.5
Hult	Barnes	2.55	+ 0.40	+ 0.23	−0.17	0.1
Yam	Larch	1.04	+ 880.84	+ 880.48	−0.36	0.1
Hult	Larch	1.56	+ 853.94	+ 851.61	−2.33	8.5
Barnes	Larch	3.72	+ 852.41	+ 851.38	−1.03	3.9
Barnes	Warren	9.33	− 344.26	− 344.61	−0.35	1.1
Larch	Warren	2.15	− 1197.05	− 1195.99	+1.06	2.4
Barnes	Rocky Butte	46.77	− 198.36	− 198.22	+0.14	0.9
Warren	Rocky Butte	7.10	+ 147.67	+ 146.39	−1.28	11.6
Barnes	River	242.10	− 333.32	− 333.36	−0.04	0.4
Rocky Butte	River	78.90	− 135.21	− 135.14	+0.07	0.4
Barnes	Harney	50.23	− 344.69	− 344.82	−0.13	0.9
Rocky Butte	Harney	102.80	− 146.66	− 146.60	+0.06	0.4
Rocky Butte	Oregonian	116.40	− 115.94	− 116.07	−0.13	2.0
River	Oregonian	245.50	+ 19.08	+ 19.07	−0.01	0.0
Barnes	Davis	3.52	+ 514.86	+ 516.81	+1.95	13.4
Warren	Davis	11.48	+ 860.72	+ 861.42	+0.70	5.7
Barnes	Star	4.57	+ 942.41	+ 945.15	+2.74	34.3
Larch	Star	14.26	+ 95.20	+ 93.77	−1.43	29.1
Davis	Star	6.55	+ 427.60	+ 428.34	+0.74	3.6
Larch	Red	4.12	+ 279.93	+ 282.42	+2.49	25.5
Davis	Red	2.74	+ 617.64	+ 616.99	−0.65	1.2
Star	Red	6.70	+ 189.10	+ 188.65	−0.45	1.3
Davis	Lam	28.91	+ 481.99	+ 482.76	+0.77	17.1
Red	Lam	3.39	− 137.31	− 134.23	+3.08	32.2
Davis	Len	3.95	+ 886.21	+ 885.30	−0.91	3.3
Red	Len	4.27	+ 269.47	+ 268.31	−1.16	5.8
Lam	Len	9.62	+ 401.47	+ 402.54	+1.07	11.0
Davis	Toutle	9.35	+ 102.09	+ 101.38	−0.71	5.1
Lam	Toutle	29.58	− 382.14	− 381.38	+0.76	17.1
Len	Toutle	9.59	− 784.05	− 783.92	−0.13	0.2
Len	Huck	3.98	− 624.84	− 624.72	+0.12	0.1
Toutle	Huck	4.30	+ 156.61	+ 159.20	+2.59	28.9
Toutle	Bel	1.90	+ 664.25	+ 667.36	+3.11	18.4
Hal	Bel	6.31	+ 560.40	+ 561.61	+1.21	9.2
Huck	Rain	18.03	− 621.29	− 622.91	−1.62	47.2
Hal	Rain	22.13	− 570.56	− 569.46	+1.10	26.8
Bel	Rain	3.06	− 1132.58	− 1131.07	+1.51	7.0
Hal	Pen	7.71	− 825.37	− 825.34	+0.03	0.0
Rain	Pen	7.06	− 255.30	− 255.88	−0.58	2.4
Hurst	Pen	30.83	+ 152.41	+ 152.91	+0.50	7.7
Tacoma south base	Pen	67.00	+ 159.54	+ 159.54	0.00	0.0
Tacoma north base	Pen	24.67	+ 157.87	+ 157.41	−0.46	5.2
Tacoma south base	Rain	9.18	+ 415.77	+ 415.42	−0.35	1.1
Tacoma north base	Rain	5.30	+ 413.37	+ 413.29	−0.08	0.3
Hurst	Bel	3.32	+ 1542.54	+ 1539.86	−2.68	23.8
Tacoma south base	Hal	6.74	+ 986.18	+ 984.88	−1.30	11.4

The probable error of an observation of weight unity derived from the preceding adjustment is ±0.78 meter. The reciprocal observations, therefore, over a line 31.7 kilometers (19⅔ miles) long determined the difference of elevation of two points with such a degree of accuracy that it is an even chance whether the error is greater or less than 0.78 meter. The probable errors for lines of other lengths were assumed to be proportional to their lengths.

The probable error of the Tacoma base was found to be ±0.17 meter. The probable error of the stations Mary and Peterson, being directly connected with the Willamette base, probably does not exceed this, and the probable error of the bench mark Oregonian must be well within this same 0.17 meter. The probable error approaches this value for stations adjacent to these and is greatest for the most remote stations. It is a safe assumption that the probable error of the other stations nowhere exceeds 1 meter.

ELEVATION OF MOUNT SHASTA.

One of the results of the vertical angle adjustments was a new elevation of Mount Shasta. This elevation was computed from reciprocal observations over six lines varying from 38 to 97 kilometers in length. The first computation was made using a mean value of the coefficient, m, of 0.066, and the results had a range of 14.6 meters. A final computation was made using the value for the coefficient of refraction which was a mean of the values computed from the lines radiating from the observing station, but corrected for the mean elevation of the line. The following are the values for the height of Mount Shasta:

From Round	1043.36+3272.69=4316.05	p=2.0
From Bally	1892.35+2424.21=4316.56	1.1
From Mears	2174.00+2142.55=4316.55	6.9
From Boliver	2451.45+1867.28=4318.73	3.7
From Sterling	2239.03+2070.00=4309.03	1.3
From Soda	1857.11+2558.37=4315.48	1.7
Weighted mean	4316.5 meters (or 14162 feet).	

ACCURACY OF VERTICAL ANGLE RESULTS IN THE UNITED STATES.

In the following table 25 sections of vertical angle results of triangulation in the United States having separate least square adjustments have been arranged in order of accuracy, the most accurate being placed first. The best test of accuracy is believed to be the probable error of an observation of unit weight. Such an observation is here considered as the reciprocal non-simultaneous observations over the length of line corresponding to unit weight, considered as 31.7 kilometers (19⅔ miles).

Sections of triangulation in order of accuracy.

Section	Season	Section of triangulation	Observations	Unknown elevations	Probable error of an observation
1	1899–1900	Ninety-eighth Meridian, Shelton-Page	39	15	±0.23
2	1902	Ninety-eighth Meridian, El Reno-Duncan	14	7	±0.24
3	1900–1903	Ninety-eighth Meridian, Page to Brown Valley	74	28	±0.39
4	1904–1905	Ninety-eighth Meridian, Brown Valley-Duluth	109	48	±0.42
5	1902	Ninety-eighth Meridian, Bowie-Stephenville	41	15	±0.42
6	1890–1899	Ninety-eighth Meridian, Salina-Shelton	87	29	±0.47
7	1902	Ninety-eighth Meridian, Duncan-Bowie	22	10	±0.52
8	1902	Ninety-eighth Meridain, Stephenville-Lampasas	35	11	±0.55
9	1906–1907	Ninety-eighth Meridian, Fergus Falls-Canada	86	29	±0.58
10	1902	Ninety-eighth Meridian, Waukomis-El Reno	18	8	±0.59
11	1905	California-Washington arc, Tacoma base northward	34	11	±0.61
12	1908–1909	Texas-California arc, Kyle-McClenny to Stanton	71	26	±0.70
13	1873–1885	California arc, Mount Toro-Santa Cruz.	28	9	±0.77
14	1903–1904	California-Washington arc, south end	83	27	±0.77
15	1903–1906	California-Washington arc, Willamette base to Tacoma base	52	18	±0.78
16	1903–1904	Ninety-eighth Meridian, Brown Valley base	31	10	±0.85
17	1904–1905	Ninety-eighth Meridian, Seguin to Laguna Madre	57	29	±0.88
18	1890–1899	California arc, San Pedro-Soledad	23	7	±0.88
19	1899–1901	Ninety-eighth Meridian, Thirty-ninth Parallel-Anthony	53	19	±0.91
20	1910–1911	Texas-California arc, Deming to California	72	26	±0.91
21	1909–1910	Texas-California arc, Stanton-Deming	106	38	±0.92
22	1873–1898	California arc, Santa Cruz-San Pedro	20	7	±1.05
23	1901–1902	Ninety-eighth Meridian, Anthony-Waukomis	16	6	±1.09
					[1] ±0.68
24	1878–1895	Thirty-ninth Parallel, Pikes Peak-Round Top	71	28	±1.20
25	1859–1892	Thirty-ninth Parallel, Point Arena-Mount Diablo	48	15	±1.83

[1] Mean.

It has been declared to be "useless to aim at a high degree of accuracy in vertical measures since the irregular variation of the refraction from hour to hour and day to day produces changes in vertical angles which affect the tens of seconds and sometimes even the minutes."[1] Should not this declaration be modified?

In considering the results in the above table it should be noted that the least accurate groups are those of the Transcontinental Arc where the observations extended over a great many days but at hours of the day when the refraction was great. The most accurate of the sections are the ones of the Ninety-eighth Meridian where the observations were confined to the hours nearest the time of minimum refraction, 11 a. m. to 3 p. m. The indiscriminate mean of the probable errors, excluding the two least accurate sections, is ± 0.68 meter or an uncertainty of 4″.43 in the zenith distance. Zenith distances, which are affected by unusual refraction to the extent of "tens of seconds and sometimes minutes," would exceed 3½ times the probable error and would be subject to rejection.

The sections where the lines are longest appear to have less accuracy, and this can be readily accounted for by the effect of the differences in the station errors between the ends of the line over which the zenith distances are observed. No effort has been made to correct the zenith distances for this difference in station errors. A second cause for the decrease in accuracy on the long lines is the necessarily longer interval between the observations at the ends of these lines allowing seasonal changes in the refraction to occur.

In conclusion, the results would indicate that the aim should be for a few accurate measures of the zenith distances on more than one day and between 12 and 2 p. m. (or better, between 10 and 12 a. m. if the lines are near the coast), with no long interval of time between the observations at the two ends of a line. (See pages 253 to 256 of Special Publication No. 4[2] for a discussion of the times of maximum and minimum refraction at coast and interior stations.)

ELEVATIONS

The datum for all the elevations is mean sea level.

The stations are in three classes: First, those fixed directly by the spirit leveling, and of which the elevations are subject to a probable error varying from 0.15 to 0.3 meters; second, the stations in the main scheme fixed by reciprocal measures of vertical angles and which are subject to probable errors varying from ±0.2 to ±1.1 meters, and, third, the intersection stations, of which the elevations are fixed by measurements of vertical angles which are not reciprocal, the intersection stations not being occupied, and whose elevations are subject to probable errors which may be great as ±3 meters in some cases.

The accuracy with which each elevation in the main scheme is determined depends mainly upon the remoteness of that station from the nearest one of which the elevation is fixed by spirit leveling, as indicated in class 1 of the following table. Station Snow Mountain west is probably least accurately determined of all the stations in the main scheme.

For a table to be used in converting feet to meters, or vice versa, see page 34.

TABLE OF ELEVATIONS

Thirty-ninth Parallel to Willamette base

Station	Point to which elevation refers	Elevation
Class 1		*Meters*
Redding astronomic station	Station mark	202.16
Gazelle astronomic station	Station mark	848.28
Central Point astronomic station	Station mark	369.92
Roseburg latitude station	Station mark	165.24
Willamette north base	Station mark	101.36
Willamette south base	Station mark	116.59

[1] See p. 282, Appendix 3, Report for 1902.

[2] The Transcontinental Triangulation, by Chas. A. Schott, Special Publication No. 4, U. S. Coast and Geodetic Survey.

TABLE OF ELEVATIONS—Continued.

Thirty-ninth Parallel to Willamette base—Continued.

Station	Point to which elevation refers	Elevation
		Meters
Class 2		
Mount Helena	Station mark	1322.1
Snow Mountain west	Top of pier	2145.7
Snow Mountain east	Station mark	2150.6
Marysville Butte	Station mark	638.0
Kent	Station mark	2032.9
Lyons	Station mark	2031.4
Bally	Station mark	1892.4
Round	Station mark	1043.4
Spur	Station mark	2766.9
Boliver	Station mark	2451.5
Mears	Station mark	2174.1
Sterling	Station mark	2239.3
Soda	Station mark	1857.4
Onion	Station mark	1597.1
Rust	Station mark	1891.2
White	Station mark	1222.7
Black	Station mark	1874.1
Scott	Station mark	1294.6
Burg	Station mark	608.7
Rose	Station mark	453.3
Fairview	Station mark	1806.3
Yellow	Station mark	746.3
Roman	Station mark	872.3
Spencer	Station mark	626.2
Mary	Station mark	1248.8
Peterson	Station mark	437.2
Twin	Station mark	389.8
Ridge	Station mark	361.0
Rauch	Station mark	202.2
Class 3		
Lassen Peak	Top	3189.9
Mount Linn	Top	2463.8
Mount St. John	Top	2057.6
Bully Choop	Top	2126.8
Crater Peak	Top	2646.5
Saw Tooth	Summit	2717.4
Thompson Peak	Top	2555.0
Russian Peak, north point	Highest summit	2494.3
Pilot Rock	Summit	1803.9
China Mountain	Summit	2606.2
Ashland Peak	Summit	2296.7
Marble Mountain	Summit	2533.3
Mount Eddy	Summit	2754.8
Mount Shasta	Top of peak	4316.3
Goose Nest	Tree-top	2398.5
Redding Courthouse	Tangent to roof	198.2
Little Shasta	Top of peak	2532.9
Black Butte	Top of cairn	1933.8
Preston Peak	Top of peak	2232.2
Greyback	Top of peak	2149.5
Siskiyou	Top of peak	2178.4
Wagner	Highest summit	2211.4
Kerby	Top	1689.5
Mount Pitt	Summit	2893.6
Lost Peak	Top	2446.2
Aspen Peak	Top	2502.0
Mount Scott	Top of peak	2717.7
Liao Rock	Top	2484.0
High Rock	Top	1893.8
Union Peak	Top	2347.9
Old Bailey	Top	2548.3
Dodson (U. S. G. S.)	Top of peak	984.5
Diamond Peak	Top of peak	2679.7
Quartz	Top of peak	1686.4
Mount Washington	Top of peak	2368.0

TABLE OF ELEVATIONS—Continued

Thirty-ninth Parallel to Williamette base—Continued

Station	Point to which elevation refers	Elevation
		Meters
Class 3—Continued		
Mount Zion	Top of peak	1406.4
North Sister	Top of peak	3068.4
Hayrick	Top of peak	2375.2
Middle Sister	Top of peak	3059.6
Nebo	Top of peak	1037.4
South Sister	Top of peak	3155.2
Ball Butte	Top of peak	2756.6
St. Mary Butte	Top of peak	2789.6
Prairie Peak	Top of peak	1047.6
Alsea Peak	Top of peak	1100.8
Cannibal	Top of peak	869.4
Herman	Top of peak	634.7
Seavies (U. S. G. S.)	Top of peak	607.3
Mount Jefferson	Top of peak	3207.2
Left Nipple	Top of peak	1243.4
Corvallis closed cupola	Bottom of cupola, top of roof	96.3
Corvallis open cupola	Bottom of cupola, top of roof	98.2
Albany Courthouse	Base, large cupola	88.1
Lebanon	Top of tall brick chimney	135.3
Capitol, Salem	Top, large part of dome	100.4

Willamette base net to Tacoma base

Class 1		
Oregonian	Top of Tower	69.22
Class 2		
Yam	Station mark	354.4
Hult	Station mark	383.3
Barnes	Station mark	383.5
Larch	Station mark	1234.9
Warren	Station mark	38.9
Rocky Butte	Station mark	185.3
River	Station mark	50.2
Harney	Station mark	38.7
Davis	Station mark	900.3
Star	Station mark	1328.7
Red	Station mark	1517.3
Lam	Station mark	1383.1
Len	Station mark	1785.6
Toutle	Station mark	1001.7
Huck	Station mark	1160.9
Hal	Station mark	1107.5
Bel	Station mark	1669.1
Rain	Station mark	538.0
Pen	Station mark	282.1
Cem	Station mark	825.8
Hill	Station mark	296.8
Fir	Station mark	345.9
Monument, General Land Survey	Station mark	289.7
Class 3		
Round Peak	Top of peak	1312.8
Thomas	Top of peak	1320.5
Forest Peak	Top of peak	671.9
White church spire	Top of square part	72.0
Monmouth Peak	Top of peak	984.6
Table Rock	Top of peak	1487.8
Arquett, cairn	Top of peak	1417.4
Squaw	Top of peak	1455.9
Chemawa tank	Foot of tank, top of tower	77.0
Sheridan	Top of peak	941.1
Fairdale	Top of peak	780.5
Mount Hood	Top of peak	3421.2
Mount Adams	Top of peak	3757.0

TABLE OF ELEVATIONS—Continued

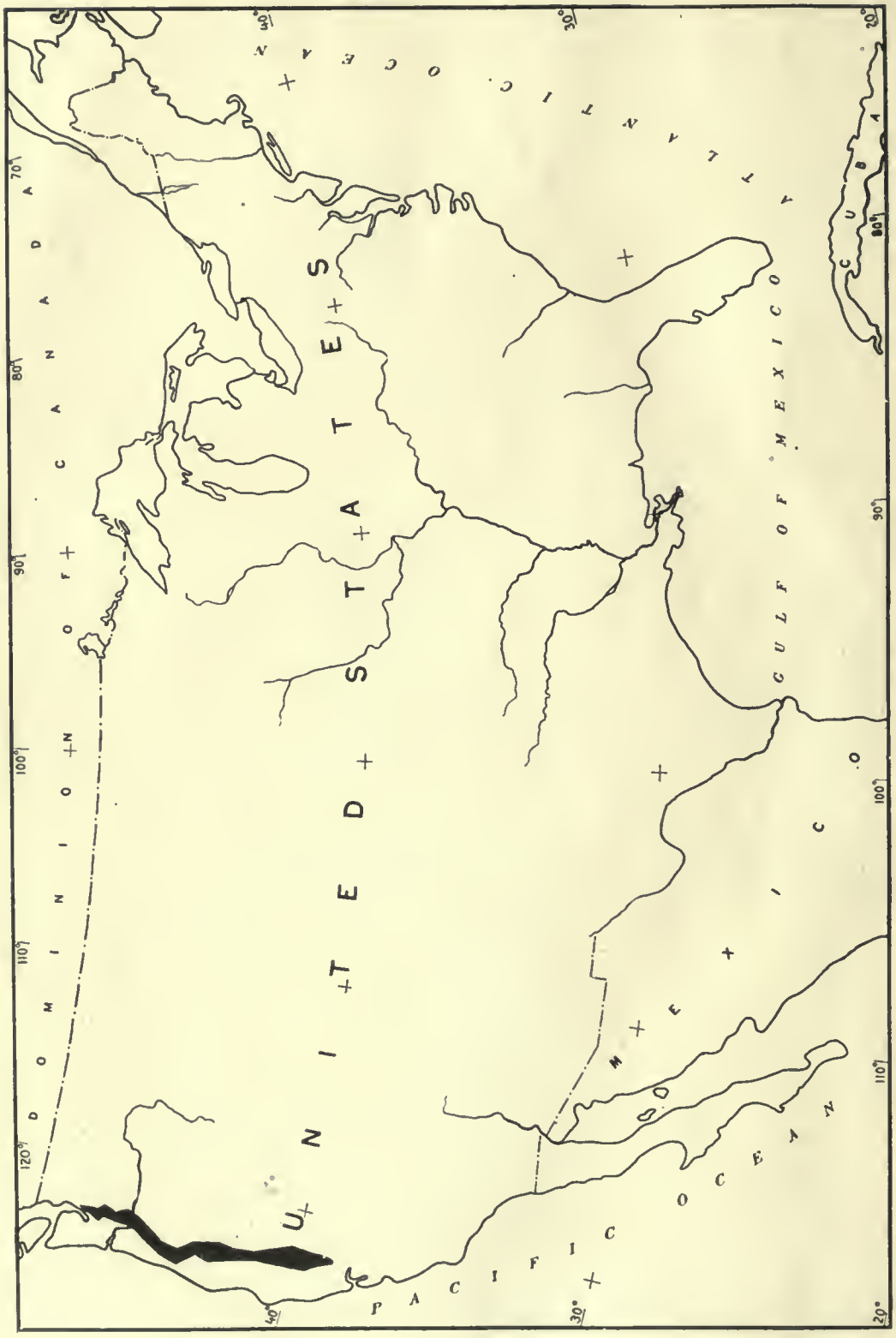
Willamette base net to Tacoma base—Continued

Station	Point to which elevation refers	Elevation
Class 3—Continued		*Meters*
Mount St. Helens	Top of peak	2955.6
Deschutes Peak	Top of peak	1318.8
High Rock	Top of peak	1733.5
Sharp Peak	Top of peak	1769.4
Mineral Peak	Top of peak	1446.5
Mount Rainier	Bare summit	4389.5
Mount Rainier	Highest point	4410.7
Goat Mountain	Top of peak	1847.8
Mitchell	Top of peak	1213.7
Eagle, cairn	Top of peak	1283.0

Tacoma base to Puget Sound

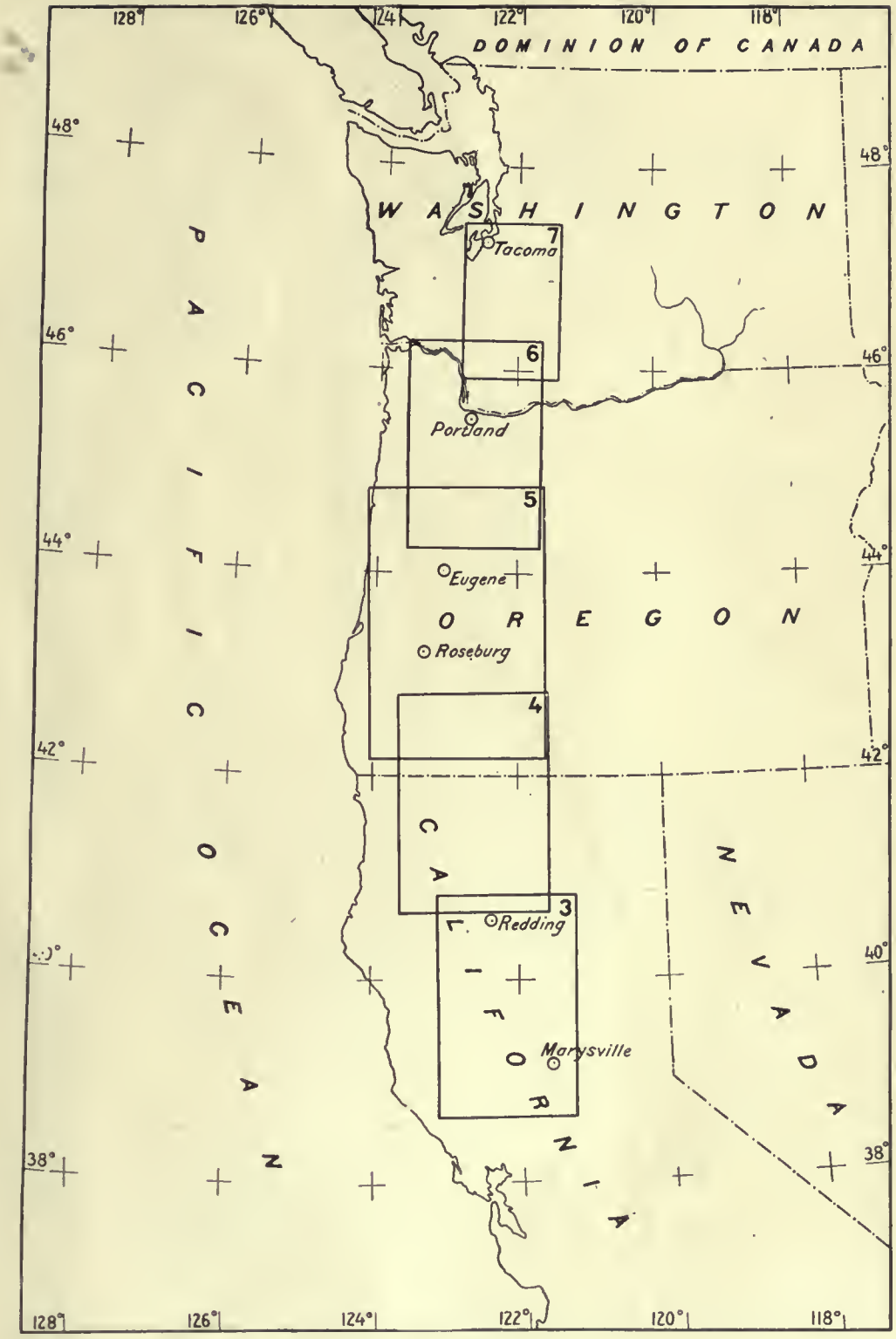
Class 1		
Tacoma City Hall	U.S.G.S.B.M.	33.52
Class 2		
Gull	Station mark	51.67
Dron	Station mark	27.59
Bos	Station mark	2.59
Kin	Station mark	102.46
Wash	Station mark	115.86
Smelt	Station mark	96.14
Neill 2	Station mark	4.02
Dash	Station mark	2.38
Piner 2	Station mark	12.24
Tacoma astronomic	Station mark	94.79
Tacoma north base	Station mark	124.70
Burn	Station mark	122.14
Tacoma south base	Station mark	122.57
Hurst	Station mark	129.20
Class 3		
Smelter stack	Top of stack	132.7
Brown Point Lighthouse	Top of light shaft	8.5
Tacoma Courthouse	Top of cupola	153.1

No. 1



Index Map.

No. 2.



Index Map.

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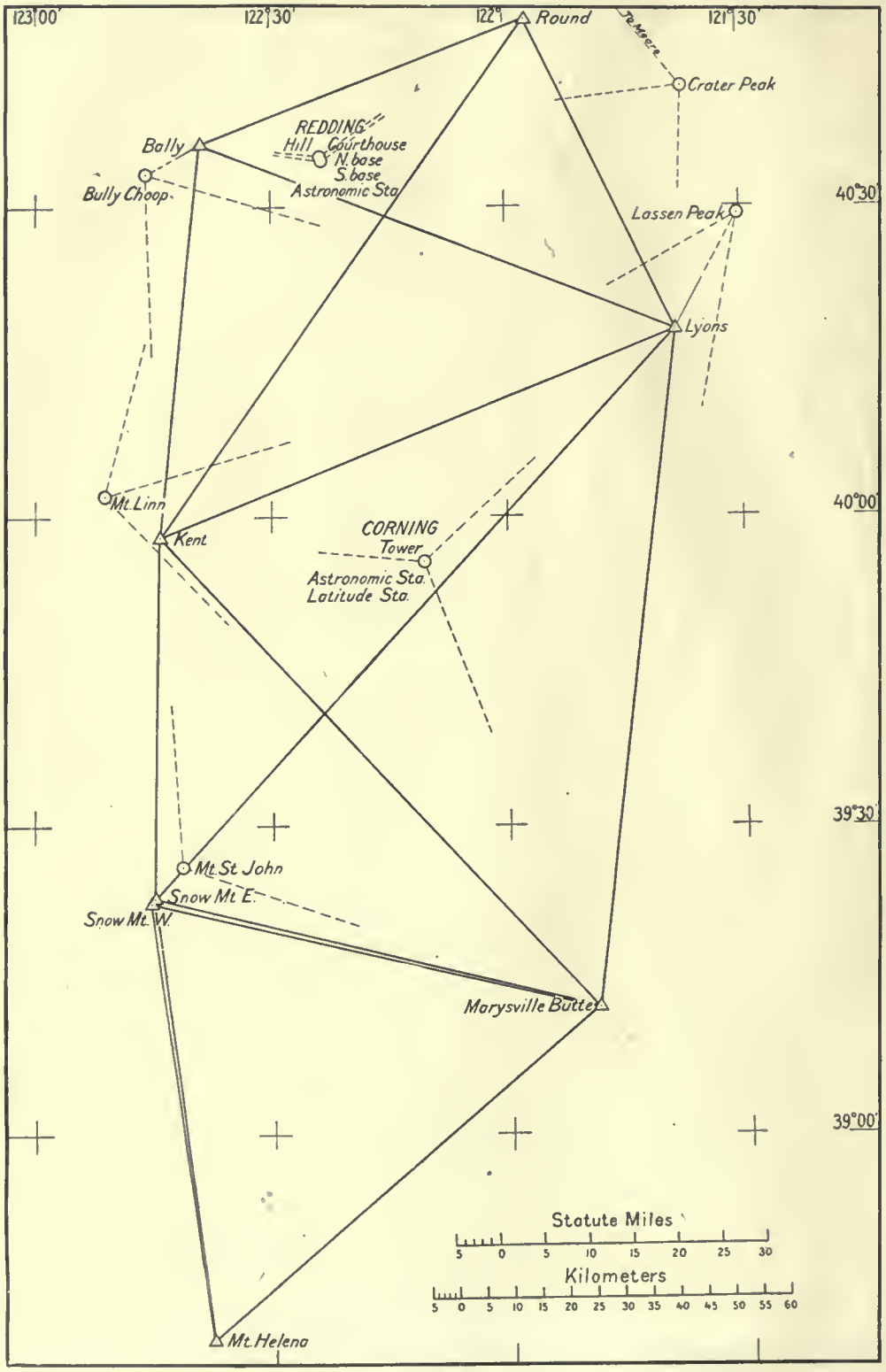

Thirty-ninth Parallel to Bally-Round.

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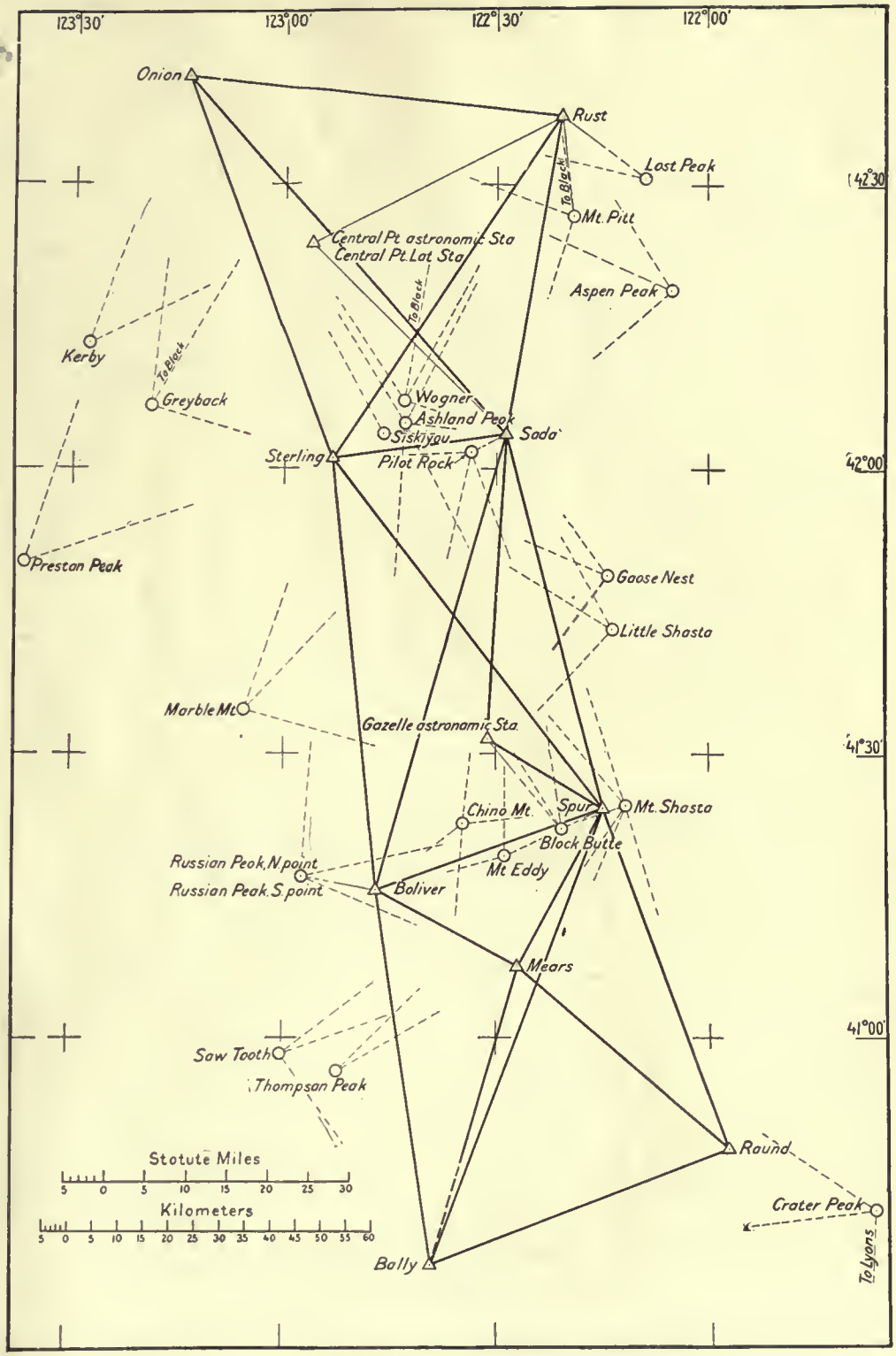

Bally-Round to Onion-Rust.

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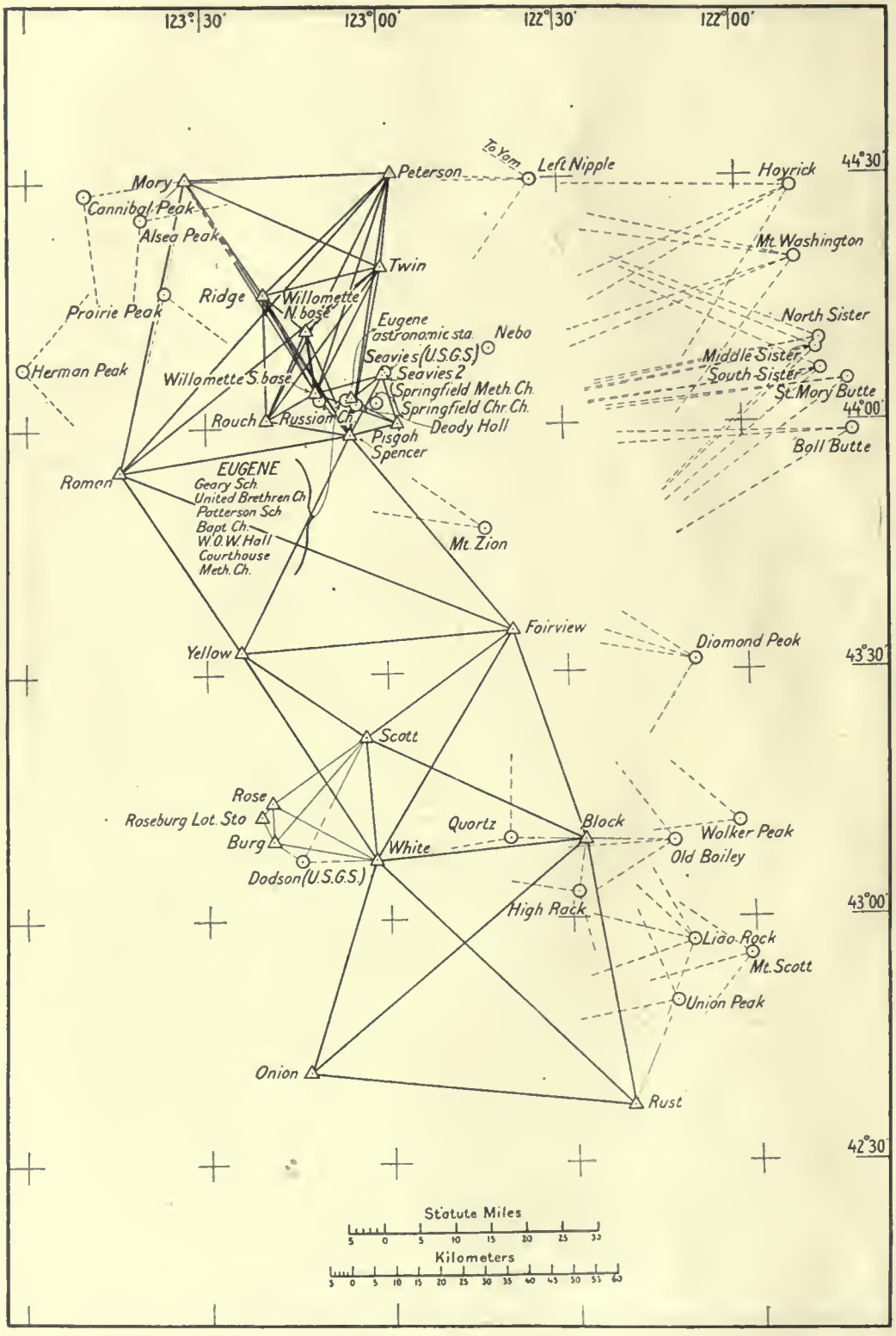

Onion–Rust to Mary–Peterson.

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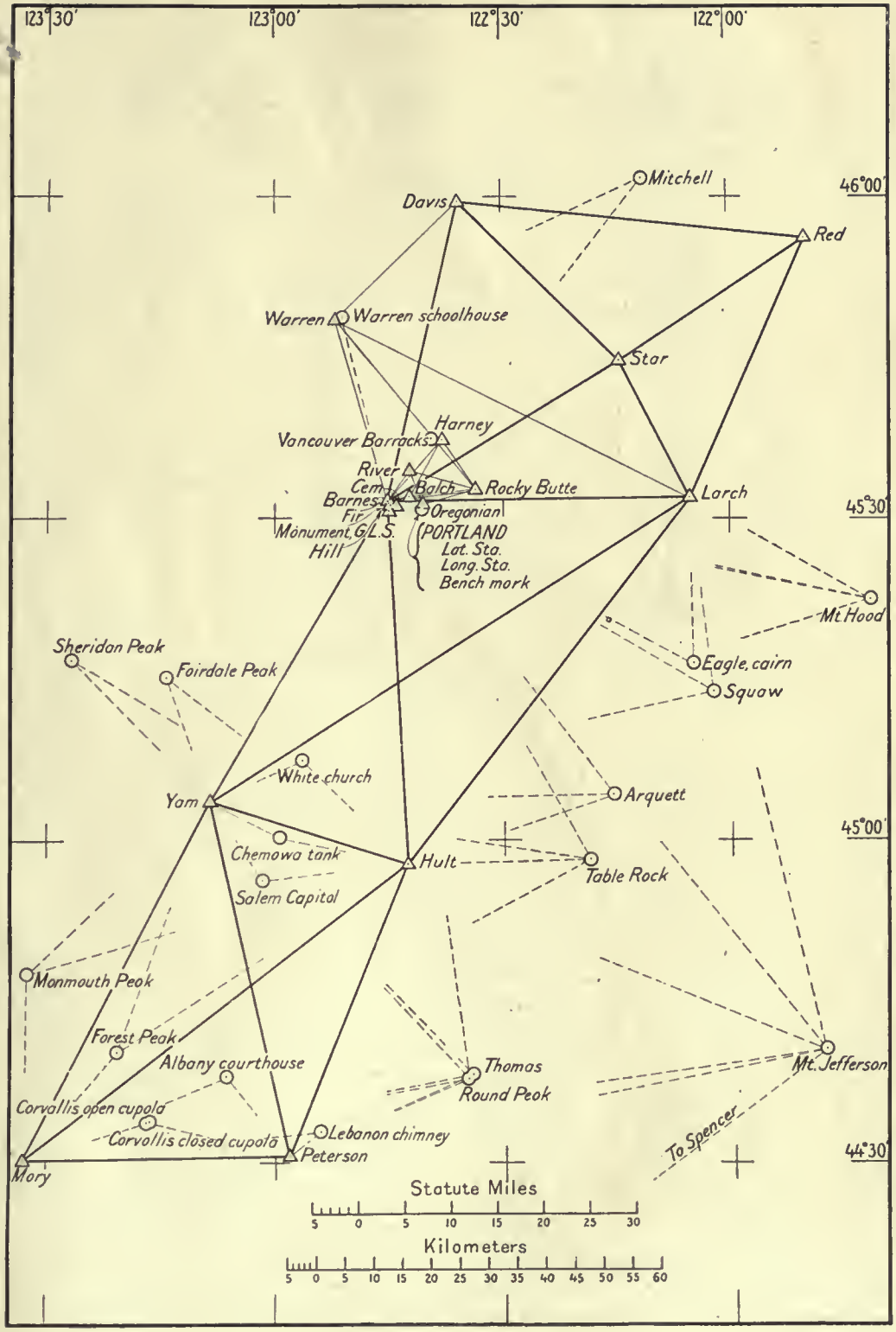

Mary-Peterson to Davis-Red.

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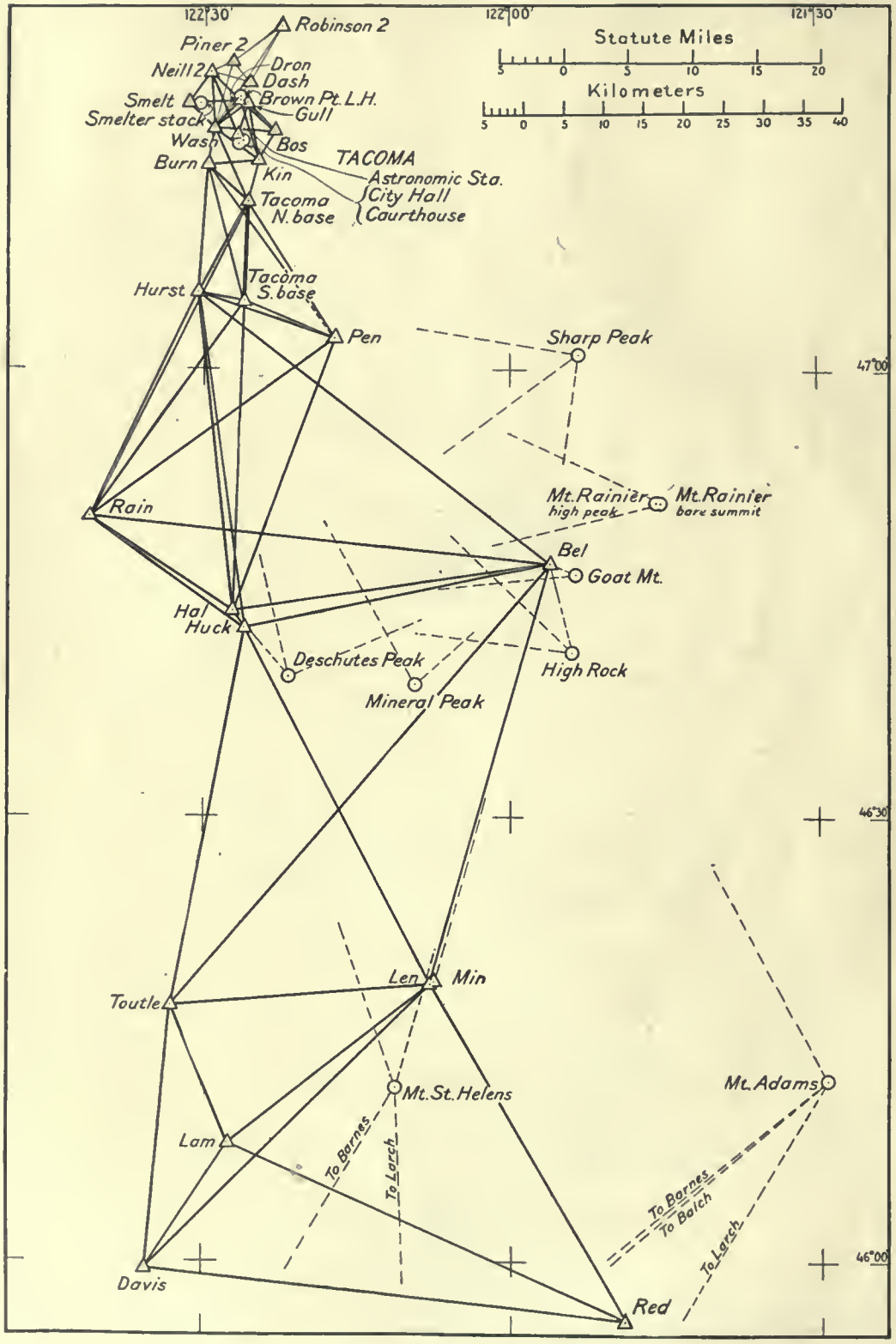

Davis-Red to Puget Sound.

Index to positions, descriptions, sketches, and elevations

Station	Position	Description	Sketch	Elevation
	Page	*Page*	*Number*	*Page*
Albany courthouse cupola	40	.....	6	66
Alsea Peak, partly cleared, wooded summit	40	.....	5	66
Arquett, cairn	41	.....	6	66
Ashland Peak, cairn	38	.....	4	65
Aspen Peak	38	.....	4	65
Astronomic station:				
Central Point	38	54	4	64
Corning	37	54	3	.....
Eugene	35	48	5	.....
Gazelle	35	45	4	64
Redding	37	54	3	64
Tacoma	37	54	7	67
Balch	41	56	6	.....
Ball Butte	39	.....	5	66
Bally	34	44	3, 4	65
Baptist Church spire, Eugene	39	55	5	.....
Barnes	36	49	6	66
Bel	36	51	7	66
Bench mark, Portland	41	.....	6	.....
Black	35	45	5	65
Black Butte, cairn	37	.....	4	65
Boliver (Cal.)	35	45	4	65
Bos	36	53	7	67
Brown Point Lighthouse	42	.....	7	67
Bully Choop	37	.....	3	65
Burg	39	55	5	65
Burn	36	52	7	67
Cannibal Peak, highest wooded summit	40	.....	5	66
Cem	41	.....	6	66
Central Point astronomic station	38	54	4	64
Central Point latitude station	38	55	4	.....
Chemawa tank	41	.....	6	66
China Mountain (not the cairn)	37	.....	4	65
Christian Church spire, Springfield	39	55	5	.....
City Hall, Tacoma	42	.....	7	67
Corning astronomic station	37	54	3	.....
Corning tower	37	54	3	.....
Corvallis, closed cupola	40	.....	6	66
Corvallis, open cupola	40	.....	6	66
Courthouse:				
Eugene, flagpole	39	55	5	.....
Redding	37	54	3	65
Tacoma, cupola	42	.....	7	67
Crater Peak	37	.....	3, 4	65
Dash	42	57	7	67
Davis	36	50	6, 7	66
Deady Hall, west tower, Eugene	39	55	5	.....
Deschutes Peak	42	.....	7	67
Diamond Peak	39	.....	5	65
Dodson (U. S. G. S.)	39	.....	5	65
Dron	36	53	7	67
Eagle, cairn	41	.....	6	67
Eugene:				
Astronomic station	35	48	5	.....
Baptist Church spire	39	55	5	.....
Courthouse flagpole	39	55	5	.....
Deady Hall, west tower	39	55	5	.....
Geary School spire	39	55	5	.....
Methodist Church	39	56	5	.....
Patterson School spire	39	55	5	.....
United Brethren Church spire	39	55	5	.....
W. O. W. Hall spire	39	55	5	.....

Index to positions, descriptions, sketches, and elevations—Continued.

Station	Position	Description	Sketch	Elevation
	Page	*Page*	*Number*	*Page*
Fairdale Peak	41	.....	6	66
Fairview	35	46	5	65
Fir	41	.....	6	66
Forest Peak, tallest trees	40	.....	6	66
Gazelle astronomic station	35	45	4	64
Geary School spire, Eugene	39	55	5	.....
Goat Mountain	42	.....	7	67
Goose Nest, tall tree	38	.....	4	65
Greyback	38	.....	4	65
Gull	36	53	7	67
Hal	36	51	7	66
Harney	41	56	6	66
Hayrick	40	.....	5	66
Herman Peak, wooded summit	40	.....	5	66
High Rock (Oreg.)	38	.....	5	65
High Rock (Wash.)	42	.....	7	67
Hill (Cal.)	37	54	3	.....
Hill (Oreg.)	41	.....	6	66
Huck	36	50	7	66
Hult	36	49	6	66
Hurst	36	51	7	67
Kent	34	44	3	65
Kerby	38	.....	4	65
Kin	36	52	7	67
Lam	36	50	7	66
Larch	36	49	6	66
Lassen Peak	37	.....	3	65
Latitude station:				
Central Point	38	55	4	.....
Portland	41	56	6	.....
Roseburg	39	55	5	64
Lebanon, tall brick chimney	40	.....	6	66
Left Nipple	40	.....	5	66
Len	36	50	7	66
Liao Rock	38	.....	5	65
Little Shasta	38	.....	4	65
Longitude station, Portland	41	56	6	.....
Lost Peak	38	.....	4	65
Lyons	34	44	3	65
Marble Mountain	38	.....	4	65
Mary	35	46	5, 6	65
Marysville Butte	34	43	3	65
Mears	35	44	4	65
Methodist Church:				
Eugene	39	56	5	.....
Springfield, spire	39	55	5	.....
Middle Sister	40	.....	5	66
Min	42	.....	7	.....
Mineral Peak	42	.....	7	67
Mitchell	41	.....	6	67
Monmouth Peak	40	.....	6	66
Monument, General Land Survey	41	56	6	66
Mount Adams	41	.....	7	66
Mount Eddy, cairn	37	.....	4	65
Mount Helena	34	43	3	65
Mount Hood	41	.....	6	66
Mount Jefferson	40	.....	6	66
Mount Linn	37	.....	3	65
Mount Pitt	38	.....	4	65
Mount Rainier, bare summit	42	.....	7	67
Mount Rainier, high peak	42	.....	7	67
Mount St. Helens	41	.....	7	67
Mount St. John	37	.....	3	65
Mount Scott	38	.....	5	65
Mount Shasta, top of	37	.....	4	65
Mount Washington	40	.....	5	65
Mount Zion	39	.....	5	66
Nebo	40	.....	5	66
Neill 2	37	54	7	67

Index to positions, descriptions, sketches, and elevations—Continued.

Station	Position	Description	Sketch	Elevation
North base:	*Page.*	*Page.*	*Number.*	*Page.*
Redding	37	54	3	.....
Tacoma	36	52	7	67
Willamette	35	48	5	64
North Sister	40	.....	5	66
Old Bailey	38	.....	5	65
Onion	35	45	4, 5	65
Oregonian	41	56	6	66
Patterson School spire, Eugene	39	55	5	.....
Pen	36	51	7	66
Peterson	35	47	5, 6	65
Pilot Rock	38	.....	4	65
Piner 2	42	57	7	67
Pisgah	35	48	5	.....
Portland:				
Bench mark	41	.....	6	.....
Latitude station	41	56	6	.....
Longitude station	41	56	6	.....
Prairie Peak, west tree	40	.....	5	66
Preston Peak	38	.....	4	65
Quartz	39	.....	5	65
Rain	36	51	7	66
Rauch	35	47	5	65
Red	36	50	6, 7	66
Redding:				
Astronomic station	37	54	3	64
Courthouse	37	54	3	65
North base	37	54	3	.....
South base	37	54	3	.....
Ridge	35	47	5	65
River	41	56	6	66
Robinson 2	42	57	7	.....
Rocky Butte	41	56	6	66
Roman	35	46	5	65
Rose	39	55	5	65
Roseburg latitude station	39	55	5	64
Round	34	44	3, 4	65
Round Peak	40	.....	6	66
Russian Church, cross	39	.....	5	.....
Russian Peak, north point	37	.....	4	65
Russian Peak, south point	38	.....	4	.....
Rust	35	45	4, 5	65
St. Mary Butte	40	.....	5	66
Salem Capitol, dome	40	.....	6	66
Saw Tooth	37	.....	4	65
Scott	35	46	5	65
Seavies (U. S. G. S.)	39	56	5	66
Seavies 2	35	48	5	.....
Sharp Peak	42	.....	7	67
Sheridan Peak, highest green tree	41	.....	6	66
Siskiyou	38	.....	4	65
Smelt	37	53	7	67
Smelter stack, 300 feet high	42	.....	7	67
Snow Mountain east	34	44	3	65
Snow Mountain west	34	43	3	65
Soda	35	45	4	65
South base:				
Redding	37	54	3	.....
Tacoma	36	52	7	67
Willamette	35	47	5	64
South Sister	40	.....	5	66
Spencer	35	46	5	65
Springfield:				
Christian Church spire	39	55	5	.....
Methodist Church spire	39	55	5	.....
Spur	34	44	4	65
Squaw, cairn	41	.....	6	66
Star	36	49	6	66
Sterling	35	45	4	65
Table Rock, cairn	41	.....	6	66

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Twin	35	47	5	65
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United Brethren Church spire, Eugene	39	55	5	.....
Vancouver Barracks flagstaff, west	41	.....	6	.....
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Walker Peak	38	.....	5	.....
Warren	36	50	6	66
Warren Schoolhouse cupola	41	.....	6	.....
Wash	36	53	7	67
White	35	46	5	65
White Church spire, west of Brooks	41	.....	6	66
Willamette north base	35	48	5	64
Willamette south base	35	47	5	64
W. O. W. Hall spire, Eugene	39	55	5	.....
Yam	36	49	6	66
Yellow	35	46	5	65